Gibbons

Volume 64
Number 3

September, 1950
Pages 195-308

$4.00 a Year
$1.25 a Number

Journal of the New England Water Works Association

ISSUED QUARTERLY

Published by
THE NEW ENGLAND WATER WORKS ASSOCIATION
73 Tremont Street, Boston 8, Massachusetts

Entered as second-class matter September 25, 1928, at the Post Office at Boston, Mass., under Act of Congress of March 3, 1879
Copyright, 1950, by the New England Water Works Association

OFFICERS
OF THE
New England Water Works Association
1950 - 1951

PRESIDENT

THOMAS R. CAMP, Consulting Engineer, Camp, Dresser & McKee, Boston, Mass.
(Term expires September 1951)

VICE PRESIDENT

FREDERICK O. A. ALMQUIST, Principal Sanitary Engineer, Connecticut State Department of Health, Hartford, Conn.
(Term expires September 1951)

STANLEY M. DORE, Assistant Chief Engineer, Allegheny County Sanitary Authority, Pittsburgh, Penna.
(Term expires September 1952)

DIRECTORS

WILLIAM B. DUFFY, Superintendent, Public Works, North Andover, Mass.
(Term expires September 1951)

ROGER G. OAKMAN, Superintendent, Water Division, Needham, Mass.
(Term expires September 1952)

ALLAN F. MCALARY, Superintendent and Treasurer, Camden & Rockland Water Company, Rockland, Maine.
(Term expires September 1953)

PAST PRESIDENTS

ARTHUR C. KING, Superintendent, Taunton Water Works, Taunton, Mass.

SIDNEY S. ANTHONY, Superintendent, Augusta Water District, Augusta, Maine.

SECRETARY

JOSEPH C. KNOX, Secretary, New England Interstate Water Pollution Control Commission, Boston, Mass.

TREASURER

WILLIAM P. MELLEY, Commissioner, Milton Water Department, Milton, Mass.

EDITOR

GEORGE C. HOUSER, 220 Clyde Street, Brookline 67, Mass.

THE Association was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of 900 men. Its membership is divided into six classes, viz.:

A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

A Junior shall be not less than eighteen years nor more than twenty-five years of age, a student or connected with water supply work.

An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

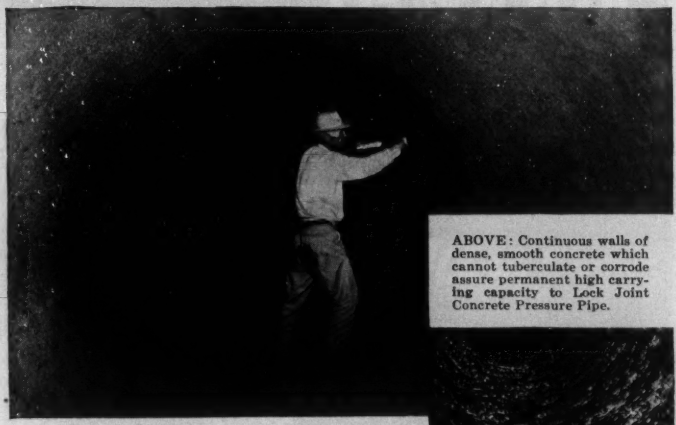
A Corporate Member shall be either a Water Board, Commission, Company or Municipal Corporation.

The initiation fees and annual dues are as follows:

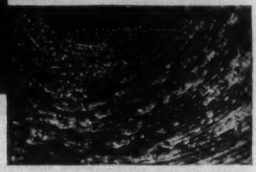
Initiation Fees		*Annual Dues*	
Members	$ 3.00	Members	$ 5.00
Juniors	1.00	Juniors	3.00
Associates	10.00	Associates	20.00
Corporate Members	10.00	Corporate Members	10.00

This Association has at least eight regular meetings each year, of which five are held in Boston, one in northern New England, one in southern New England, and one, the annual convention, held in September on such date as the Executive Committee may designate.

CONCRETE *is the answer to your main problem*



ABOVE: Continuous walls of dense, smooth concrete which cannot tuberculate or corrode assure permanent high carrying capacity to Lock Joint Concrete Pressure Pipe.



ABOVE: The tuberculated condition of this metallic pipe reduces its carrying capacity 50%.

Tuberculated mains—corroded mains—leaky mains—all cost municipalities, taxpayers and industry immense sums every year in added pumping costs, maintenance and repairs. Yet, by the use of Lock Joint Concrete Pressure Pipe, all of this unnecessary expense could be eliminated.

1. LOCK JOINT PRESSURE PIPE does not tuberculate...

RESULT
- **No excessive pumping costs**
- **No periodic cleaning costs**
- **No loss of income from inadequate delivery of water.**

2. LOCK JOINT PRESSURE PIPE does not corrode...

RESULT
- **No cost for major repairs**
- **No cost for periodic patchwork**
- **No loss of revenue while the line is closed for repair.**

Consider these facts when you plan your next water supply or transmission main and specify Lock Joint—the pressure pipe of perpetual economy.

LOCK JOINT PIPE COMPANY

Est. 1905

P.O. Box 269, East Orange, N. J.

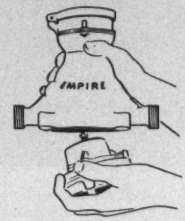
Pressure Pipe Plants:
Wharton, N. J. • Turner, Kan. • Detroit, Mich.

BRANCH OFFICES: Casper, Wyo. • Cheyenne, Wyo. • Denver, Col. • Kansas City, Mo. • Valley Park, Mo. • Chicago, Ill. Rock Island, Ill. • Wichita, Kan. • Kenilworth, N. J. • Hartford, Conn. • Tucumcari, N. Mex. • Oklahoma City, Okla. • Tulsa, Okla.

Lock Joint Pipe Company for over forty years has specialized exclusively in the manufacture of reinforced concrete pipe for water supply and transmission mains as well as for sewers, culverts and subaqueous installations.

ROCKWELL
EMPIRE
Oscillating Piston
WATER METERS

COST LESS TO REPAIR

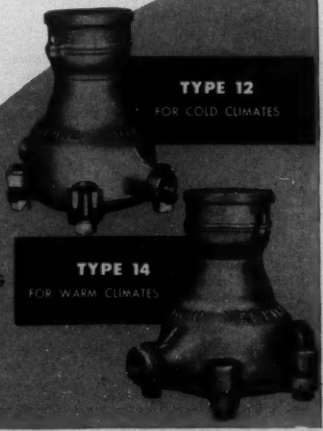


ALL INTERIOR PARTS ASSEMBLE AS A COMPLETE UNIT FOR INSERTION IN CASE

Here is the simple arrangement of measuring chamber and gear train parts in Rockwell-built Empire water meters. Note there are only three interior castings. They assemble without the use of any screws. Fitting is quick, positive. The assembled mechanism can be tested for its free running qualities prior to being bolted in the meter case.

Empire meters have fewer parts—better parts—exactingly interchangeable parts. Dismantling and assembly is quick, easy—to save time and money in meter shop operations. Thus the noted initial long life of these meters can be economically renewed to give many more years of uninterrupted service.

- SIMPLE CONSTRUCTION
- INTERCHANGEABILITY
- FEWEST WORKING PARTS



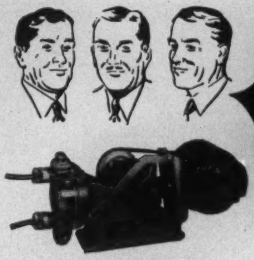
TYPE 12
FOR COLD CLIMATES

TYPE 14
FOR WARM CLIMATES

Rockwell MANUFACTURING COMPANY
PITTSBURGH 8, PA.

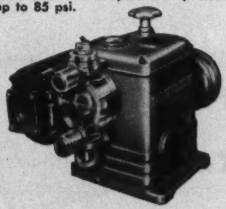
Atlanta Boston Chicago Columbus Houston
Kansas City Los Angeles New York
Pittsburgh San Francisco Seattle Tulsa

IN OUR TOWN WE PREFER SODIUM FLUORIDE SOLUTIONS!
SODIUM SILICO FLUORIDE SLURRY IS THE CHOICE FOR OUR CITY!
WE USE HYDROFLUORIC ACID IN OUR MUNICIPALITY!



We ALL use
%PROPORTIONEERS% Fluoridation Equipment

HEAVY DUTY MIDGET—Ideal chemical feeder for fluoridation of small or medium sized water systems at pressures up to 85 psi.



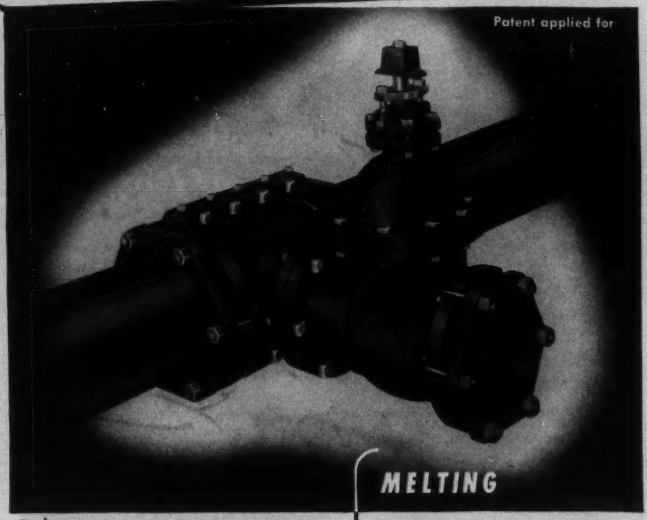
HEAVY DUTY CHEM-O-FEEDER—available in Simplex, Duplex, and Triplex models, for pressures to 125 psi and for the widest range of fluoridation requirements.

%PROPORTIONEERS% OFFERS A COMPLETE LINE OF ACCURATE EQUIPMENT WITH ACCESSORIES FOR AUTOMATIC AND PROPORTIONAL HANDLING OF FLUORIDE COMPOUNDS.

Whatever fluoride compound you select, %Proportioneers% has the Chemical Feeder to do the fluoridation job accurately, safely, dependably. Regardless of the size of the community—small town, city, or great municipality—it's the natural thing for water works men to pick %Proportioneers% Feeders for fluoridation of water supplies. Buyers of %Proportioneers% equipment profit from our more than five years of experience in this modern water treatment technique. For engineering Bulletin SAN-9, the complete story on fluoride feeding, write %Proportioneers, Inc.%, 366 Harris Ave., Providence 1, Rhode Island.

% PROPORTIONEERS, INC. %

THE FIRST MECHANICAL JOINT TAPPING SLEEVE AND VALVE



See It At Booths 228 and 230 at the A.W.W.A. Convention

ELIMINATES { MELTING / POURING / CAULKING

A new *all* Mechanical Joint Tapping Sleeve and Valve, installed quickly and easily even by untrained workmen using a ratchet wrench. There are no joints to pour and caulk.
Installation can be made in wet trenches in any kind of weather.
The "Stuffing Box" type joints require no cutting or scarfing of rubber gaskets on job. Assemble Sleeve on main—attach the Valve, the installation is complete and the joints are permanently bottle-tight.

32

GATE VALVES
CHECK VALVES
FIRE HYDRANTS
INSERTING VALVES
TAPPING SLEEVES AND VALVES
WATER SERVICE BRASS GOODS

THE A. P. SMITH MFG. CO.
ESTABLISHED 1874
EAST ORANGE, NEW JERSEY

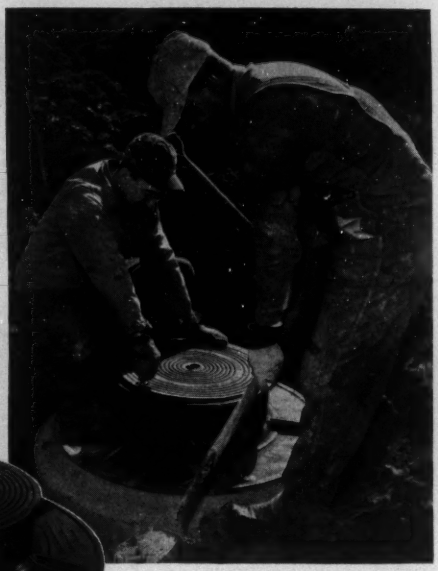
FLOOR STANDS
INDICATOR POSTS
TAPPING MACHINES
INSERTING MACHINES
PIPE CUTTING MACHINES
CORPORATION TAPPING MACHINES

FORD

MONITOR COVERS

FIT 24", 30", AND 36"

METER PIT BARRELS



WRITE FOR CATALOG

Ford Catalog No. 50 contains full information. Send for your copy today. FREE.

For covering large meter pits the Monitor Cover is most useful. With lid opening large enough to permit meter reader to enter setting, this cover is used over pits containing 1½" or 2" meters, or multiple settings of smaller meters. An inner lid is available if extra frost protection is desired.

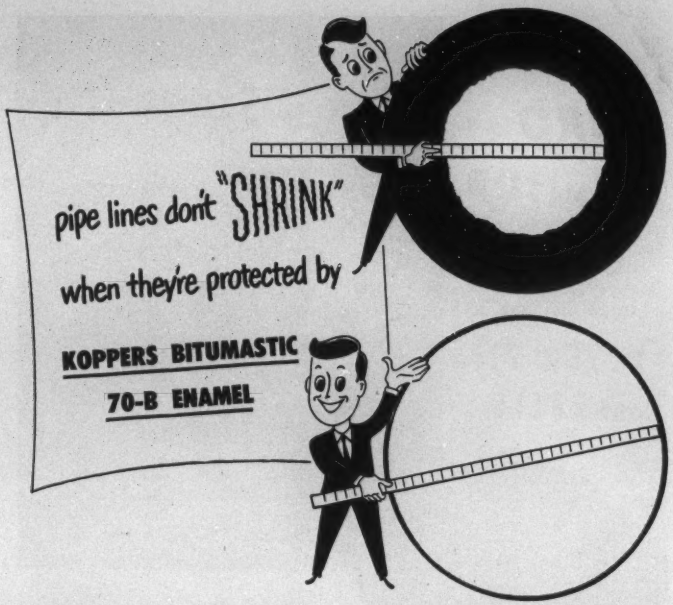
The cover is equipped with the Ford Lifter Worm Lock that opens lid easily, even when frozen.

FOR BETTER WATER SERVICES

FORD

Manufactured by THE FORD METER BOX COMPANY, INC.

Wabash, Indiana



● It isn't necessary to specify oversized pipe for your large-diameter water lines to meet anticipated "shrinkage" in flow capacity due to tuberculation.

It's far less expensive to *prevent tuberculation* by coating the pipe interior with a glass-smooth spun lining of Koppers Bitumastic® 70-B Enamel. Then you can select pipe size solely on the basis of desired capacity.

And Bitumastic gives you a lastingly-high coefficient of flow that reduces pumping costs . . . results in savings that more than pay the cost of the lining.

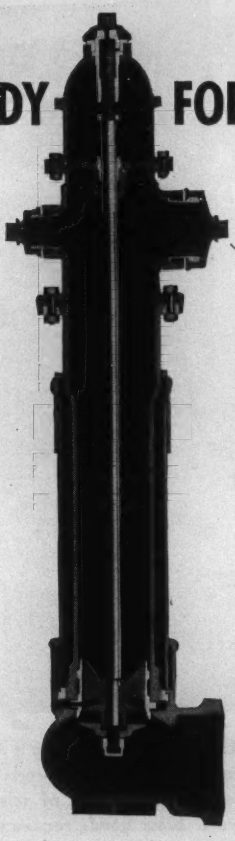
Koppers Bitumastic 70-B Enamel also makes it unnecessary for you to specify additional wall thickness to compensate for corrosion. An exterior coating of Bitumastic 70-B Enamel, combined with the spun lining, forms a barrier against all types of corrosion, inside the pipe and out.

Make certain your community is getting its money's worth of proper protection—specify Koppers Bitumastic 70-B Enamel for your large-diameter lines.

KOPPERS BITUMASTIC ENAMELS
REG. U.S. PAT. OFF.

KOPPERS COMPANY, INC., Tar Products Division, Dept. 906T, Pittsburgh 19, Pa.

READY FOR INSTANT USE



There's no place where rust or ice can form to interfere with the functioning of the Mathews Modernized Hydrant. The operating thread is above the water, separated from it by the stuffing box plate. This plate is cast integral with the nozzle section and, with the packing, provides a positively leakproof construction.

MATHEWS MODERNIZED HYDRANTS SET THE PACE: Easily maintained, because simple in construction • All working parts contained in replaceable barrel • Stuffing box cast integral with nozzle section • Head can be turned 360° • Replaceable head Nozzle outlets are easily changed Nozzle levels can be raised or lowered without excavating • Protection case of "Sand-Spun" cast iron for extra strength, toughness, and elasticity Operating thread only part to be lubricated • A modern barrel makes an old Mathews good as new • Available in sizes 4" to 16" with mechanical joint pipe connections

MATHEWS HYDRANTS

THE FIREMAN'S FRIEND

Made by R. D. Wood Company

Public Ledger Bldg., Independence Square

Phila. 5, Pa.

Manufacturers of "Sand-Spun" Pipe (centrifugally cast in sand molds) and R. D. Wood Gate Valves

YES...

IT'S MEANT FOR YOU!!

This new MUELLER Blue Top Catalog is meant to provide engineers and water works men with a simple, accurate means of selecting their water works brass goods requirements. It illustrates the complete Blue Top Line and gives full dimensional data on each item. You'll find it invaluable for constant reference, so if you haven't a copy handy right now, don't delay — write for one today.

DEPENDABLE SINCE 1857 FULLY WARRANTED OUR 91st YEAR

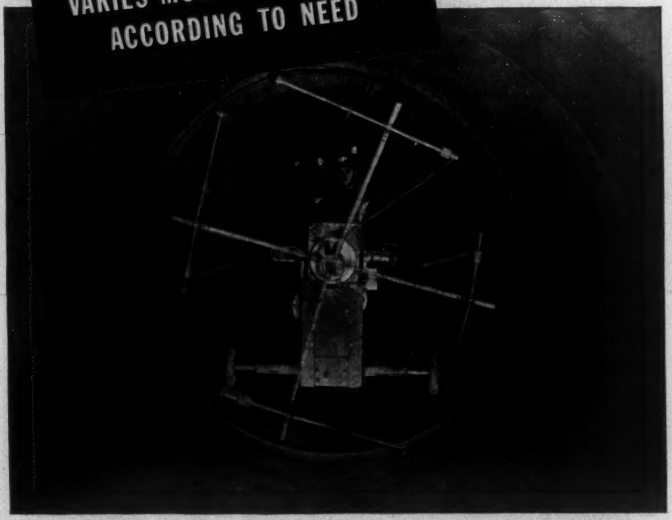
MUELLER CO.

EASTERN SALES OFFICE, 1522 EMPIRE STATE BLDG., N. Y., N. Y.
MAIN OFFICE AND FACTORY ..... DECATUR, ILLINOIS
OTHER FACTORIES: Los Angeles, Cal., Chattanooga, Tenn., Sarnia, Ont., Canada

CENTRILINE

VARIES MORTAR-THICKNESS ACCORDING TO NEED

▶▶▶ PIPE LINING FACTS NO. 4



The Centriline process is extremely flexible in providing linings of variable thickness in accordance with the degree of protection necessary. The thickness of the lining is controlled in inverse proportion to the forward speed of the Centrifugal machine. Thus, when cleaning reveals sections of a main particularly affected by electrolysis or corrosion and strengthening is desirable, an increase in thickness is obtained by slowing the speed of the machine.

No matter what plate thickness or plate conditions are encountered—serious deterioration and penetration included—the flexibility of the Centriline Process restores capacity to better than new and vastly increases the life expectancy of the pipeline.

▲▲ **WRITE TODAY FOR THE 28 PAGE CENTRILINE CATALOG**

Reg. U. S. Pat. Off.

CENTRILINE CORPORATION

A subsidiary of Raymond Concrete Pile Co.

142 CEDAR STREET • NEW YORK 6, N. Y.

CEMENT MORTAR LININGS FOR WATER MAINS

Centrifugally Applied in Strict Conformity with A. W. W. A. Specifications

Branch Offices in all Principal Cities in the United States and Latin America

ADVANCED BADGER ENGINEERING
brings you BADGER METER TESTERS

Make a place in your set-up for Badger Meter Testers. You need them . . . 1 — Because they faithfully record meter accuracies and help you to increase revenue... 2 — Because, with their Visible Rate-of-Flow Indicators, they accurately indicate rates of flow from 1/16-gallon to 160 gallons per minute . . . positively, not just proportionally . . . 3 — Because they act as insurance against water revenue losses.

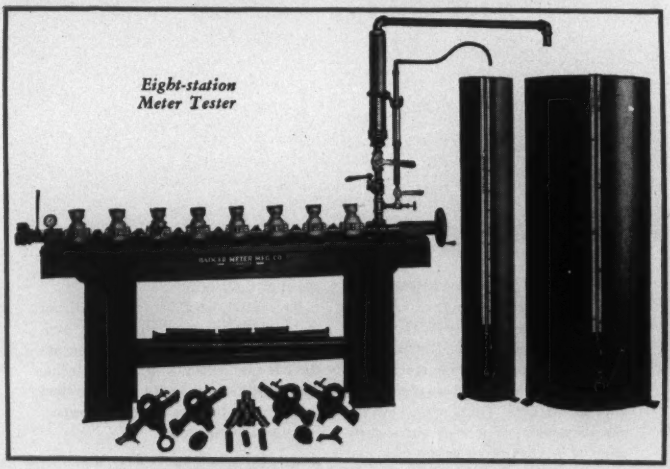
BADGER METER TESTERS are the only completely equipped testers made. NO EXTRAS TO BUY.

Four sizes available . . . to handle two, four, six or eight ⅝-inch meters of any make, as well as varying quantities of larger sizes up to and including 2-inch.

Depending on your requirements you may select any of these four combinations of BADGER METER TESTERS . . . 1 — With BOTH large and small Visible Flow Indicators and BOTH 10-gal. and 100-gal. calibrated tanks; 2—With large indicator only; 3 — With small indicator only; 4 — Without either indicator.

Spacer pipes are furnished for fill-in whenever it is necessary to test fewer than the total meter-capacity of the tester.

In every detail BADGER METER TESTERS are soundly engineered to serve you long and accurately. Write for further information and prices.



Eight-station Meter Tester

BADGER METER MFG. CO., Milwaukee 10, Wis.

Branch Offices: New York City • Philadelphia • Worcester, Mass. • Savannah, Ga. Cincinnati • Kansas City • Waco, Texas • Salt Lake City, Utah Guthrie, Okla. • Seattle, Wash. • Los Angeles

BADGER *Water* METERS

"MEASURING THE WATER OF THE WORLD"

First FOR ACCURACY • LOW-COST MAINTENANCE • DURABILITY • SENSITIVITY

Table of Contents

PAGE

Damages Paid on Account of the Diversions from the Ware and Swift Rivers for Water Supply of the Boston Metropolitan District

By Walton H. Sears 195

The Requirements of a Pipe Joint for Water Lines

By Arthur Hicks 291

Pressure Filtration

By Ernest E. Tankard 299

Telling the Public about "Water"

By Martin E. Flentje 302

Proceedings:

April 1950 Meeting 308

May 1950 Meeting 308

New England Water Works Association
ORGANIZED 1882

VOL. LXIV SEPTEMBER, 1950 NO. 3

This Association, as a body, is not responsible for the statements or opinions of any of its members

DAMAGES PAID ON ACCOUNT OF THE DIVERSIONS FROM THE WARE AND SWIFT RIVERS FOR WATER SUPPLY OF THE BOSTON METROPOLITAN DISTRICT

BY WALTON H. SEARS*

[*Excerpts read September 15, 1949.*]

IN PREPARING this paper the writer has been guided by the assumption that similar damage claims will arise in the future in connection with other water-supply developments, and the selection of facts for reporting has been made on the basis of possible value to those engaged in the settlement of such future claims. The basic facts in each case have been recorded, together with the settlement figures. Methods of estimating damages employed by various experts are reported in some detail where such are unusual. Legal aspects as they appear in the Courts' charges to the jury and in the opinion of the Supreme Court, in the one case that was carried to that court, are also recorded. The names of witnesses have been omitted. To have referred to each by name would have simplified the text but it has seemed wiser to leave out personalities.

* * *

The recent addition to the water supply of the Metropolitan District of Boston is from the Ware and Swift Rivers, which are tributary to the Chicopee, which flows into the Connecticut. The waters taken are, therefore, diverted from their natural watersheds and all riparian owners lying below the points of diversion are deprived of the water taken. Under common law each riparian owner is entitled to receive the water as it runs and to make use of it as he sees fit, but must pass it along to the next lower riparian owner substantially undiminished in volume and not materially impaired as to quality. Hence, a diversion from one watershed to another is an

*Consulting Engineer, 160 Pleasant St., Arlington, Mass.; formerly Mechanical Engineer, Metropolitan District Water Supply Commission, Boston, Mass.

infringement upon riparian rights and the taking of the waters of the Ware and Swift Rivers furnished a just and proper basis for damage claims against the Commonwealth, which, through its Metropolitan District Water Supply Commission (hereinafter referred to as the Commission), made the takings and constructed the works for diverting and utilizing the water. It is the purpose of this paper to record the settlement of these claims—some by agreement, others by litigation—such details as appear to be worthy of note being included.

Chapter 375 of the Acts of 1926 authorizes the diversion at Coldbrook of the "flood waters" of the Ware River, flood waters being defined as the flow in excess of 85 mgd (million gallons per day) at the point of diversion. The act further limits the diversion to the months of December to May, inclusive, but provides that diversions between May 31 and December 1 in any year may be made, if permitted by the Massachusetts Department of Public Health.

Chapter 321 of the Acts of 1927 authorizes diversion from the Swift River of all flow except such as is necessary to maintain a flow of 20 mgd at the village of Bondsville, located about 6 miles downstream from Winsor Dam, and requires the release daily into the Swift River of enough water to maintain 20 mgd at that point. The drainage area tributary to the Swift River between Winsor Dam and Bondsville amounts to about 8 sq mi. Hence, the required release at Winsor Dam is that part of 20 mgd which is not contributed by the 8 sq mi tributary between the dam and Bondsville, and varies from nothing during periods of high flow to very nearly the full 20 mgd during periods of drought. The estimated average required release, based on long-term observations of river flow, is about 12 mgd.

In addition to the foregoing limitations upon diversions imposed by the Massachusetts legislation, the War Department in granting federal authority for diversions from both rivers has restricted diversions from the Ware River to the period of October 15 to June 15 and, in the case of the Swift River, required, during the period of June 1 to November 30, the release to the Swift River of 70 cubic feet per second (about 45 mgd) when the flow of the Connecticut River at Montague, Mass., is between 4,650 and 4,900 cfs (cubic feet per second), and 110 cfs (about 71 mgd) when below 4,650 cfs. It is not believed that the War Department "restrictions" were taken into

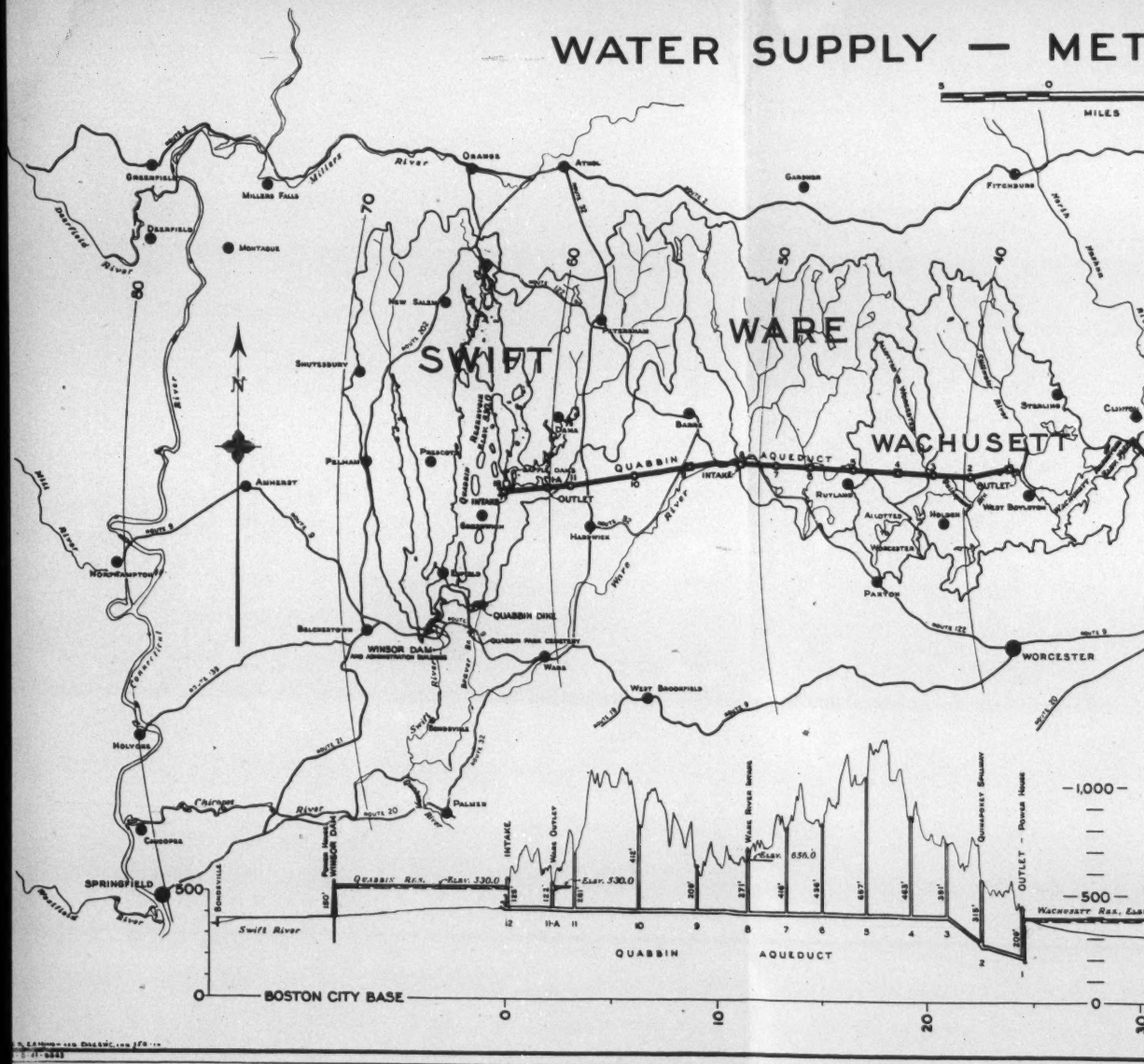
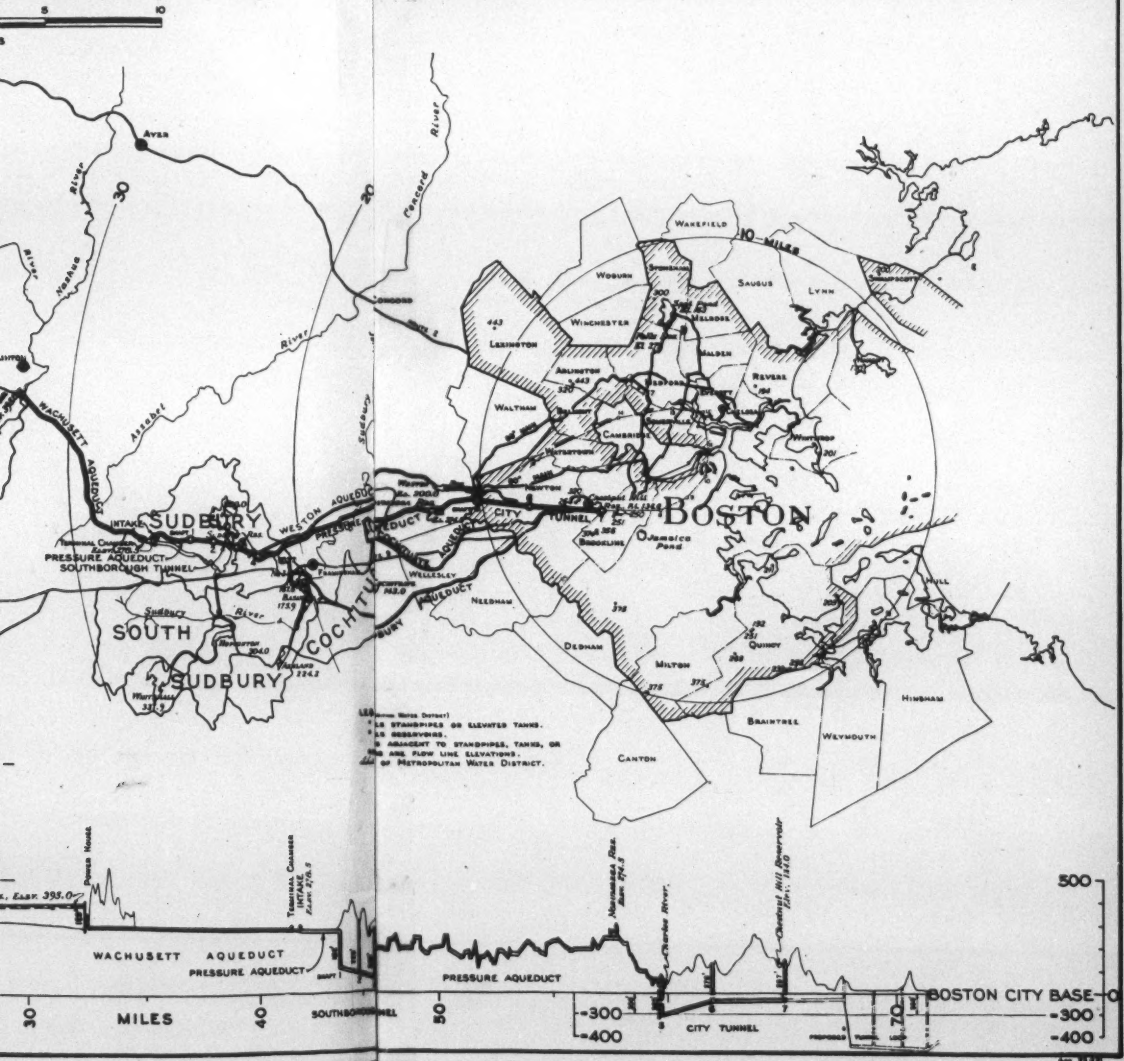

WATER SUPPLY — MET
MILES
SWIFT
WARE
WACHUSETT
QUABBIN AQUEDUCT
INTAKE
OUTLET
QUABBIN DIKE
WINSOR DAM
AND ADMINISTRATION BUILDING
QUABBIN PARK CEMETERY
QUABBIN RES. ELEV. 530.0
WARE RIVER INTAKE
ELEV. 656.0
QUINAPOXET SPILLWAY
OUTLET - POWER HOUSE
WACHUSETT RES. ELEV.
BOSTON CITY BASE
SPRINGFIELD
WORCESTER
AMHERST
NORTHAMPTON
HOLYOKE
CHICOPEE
GREENFIELD
DEERFIELD
MILLERS FALLS
MONTAGUE
ORANGE
ATHOL
GARDNER
FITCHBURG
NEW SALEM
PETERSHAM
SHUTESBURY
PELHAM
PRESCOTT
BARRE
STERLING
CLINTON
RUTLAND
ALLOTTEE
HOLDEN
WEST BOYLSTON
PAXTON
HARDWICK
BELCHERTOWN
WARE
WEST BROOKFIELD
PALMER
BONDSVILLE
Swift River
Chicopee River
Connecticut River
Millers River
Deerfield River
Mill River
Westfield River
Ware River
Quaboag River
North Nashua River
N

FIG. 1.

TROPOLITAN OSTON



1.

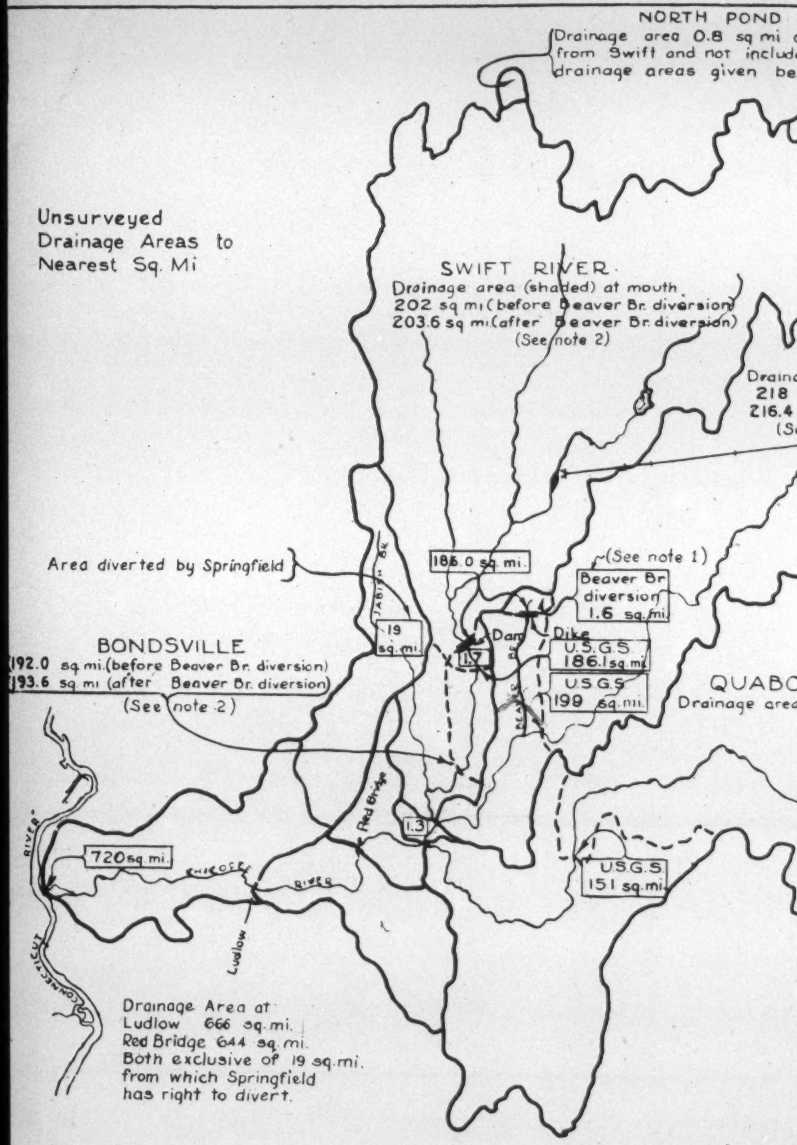
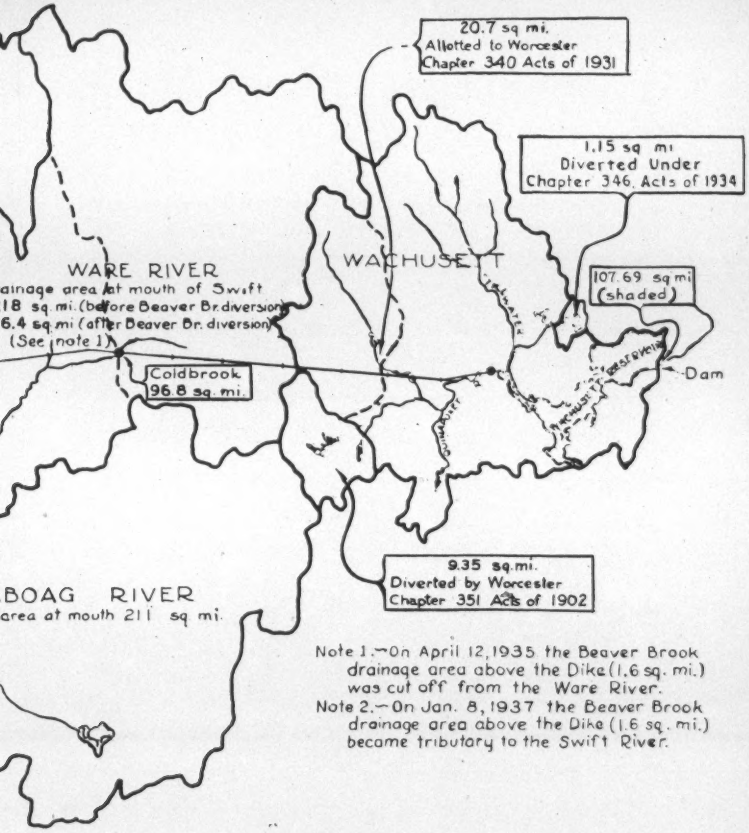

NORTH POND
Drainage area 0.8 sq mi
from Swift and not includ
drainage areas given be
Unsurveyed
Drainage Areas to
Nearest Sq. Mi
SWIFT RIVER
Drainage area (shaded) at mouth
202 sq mi (before Beaver Br. diversion)
203.6 sq mi (after Beaver Br. diversion)
(See note 2)
Drainc
218
216.4
(S
Area diverted by Springfield
185.0 sq. mi.
(See note 1)
Beaver Br.
diversion
1.6 sq. mi.
Dam
Dike
U.S.G.S.
186.1 sq mi
USGS
199 sq. mi.
19
sq. mi.
BONDSVILLE
192.0 sq. mi. (before Beaver Br. diversion)
193.6 sq mi (after Beaver Br. diversion)
(See note 2)
QUABO
Drainage area
Red Bridge
1.3
720 sq. mi.
USGS
151 sq. mi.
CONNECTICUT
RIVER
CHICOPEE
RIVER
Ludlow
Drainage Area at
Ludlow 666 sq. mi.
Red Bridge 644 sq. mi.
Both exclusive of 19 sq. mi.
from which Springfield
has right to divert.
RMG

FIG. 2.

D
ni diverted
luded in
below.



Note 1.—On April 12, 1935 the Beaver Brook drainage area above the Dike (1.6 sq. mi.) was cut off from the Ware River.

Note 2.—On Jan. 8, 1937 the Beaver Brook drainage area above the Dike (1.6 sq. mi.) became tributary to the Swift River.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION

DRAINAGE AREAS

CHICOPEE, SWIFT, WARE, QUABOAG RIVERS & WACHUSETT RES.

SCALE: APPROXIMATELY 1 INCH = 4 MILES.

APRIL 12, 1944

FILE 1.0P Acc. 27702

G. 2.

consideration in reaching agreements in those cases settled amicably.

Figure 1 shows in plan and profile the completed water-supply system of the Boston Metropolitan District and the relation thereto of the additions from the Ware and Swift Rivers. The system and its construction have been described in numerous papers presented before this association.

Figure 2 shows the outline and areas of the watersheds pertinent to a discussion of the authorized diversions and the damage claims resulting therefrom.

The drainage area of the Ware River at Coldbrook is 96.8* sq mi. The average run-off at that point during the years 1928 to 1941, inclusive, was about 108 mgd or 167 cfs. The average permissible diversion, on the assumption that diversion was permissible the year round, during that period amounted to about 51 mgd or 79 cfs, which was about 47% of the total flow. This figure, while interesting, is of no importance and is misleading in considering the effects of diversion upon lower riparian owners, since a considerable part of the water which is actually diverted is taken during freshet flows and could not be used by them in any event. In fact, diversion sometimes is a real benefit to riparian owners in reducing downstream flood heights.

The natural drainage area of the Swift River at Winsor Dam is about 184 sq mi and the total drainage area of Quabbin Reservoir, which is formed by Winsor Dam and Quabbin Dike, is about 186 sq mi, since the construction of Quabbin Dike flooded about 2 (actually 1.6) sq mi of the drainage area of Beaver Brook, a tributary of the Ware River. On the basis of long-term records of flow (1913-1936, incl.) of the Swift River at West Ware, a mile or two below Winsor Dam, where the natural drainage area is 186 sq mi, it is estimated that the average flow prior to the construction of Winsor Dam was about 195 mgd or 303 cfs, of which about 183 mgd (284 cfs) or 94% could have been diverted under the Massachusetts law.

The Swift River joins the Ware River near the village of Three Rivers in the town of Palmer and about half a mile below their point

*This is a final figure. At the time of the settlements it was taken at 98 sq mi, which figure appears in this paper.

of confluence the Quaboag River joins them, from which point the resulting stream is known as the Chicopee River. Both the Ware and Chicopee Rivers are highly developed industrially, and a large duck mill and bleachery were located at Bondsville on the Swift River.

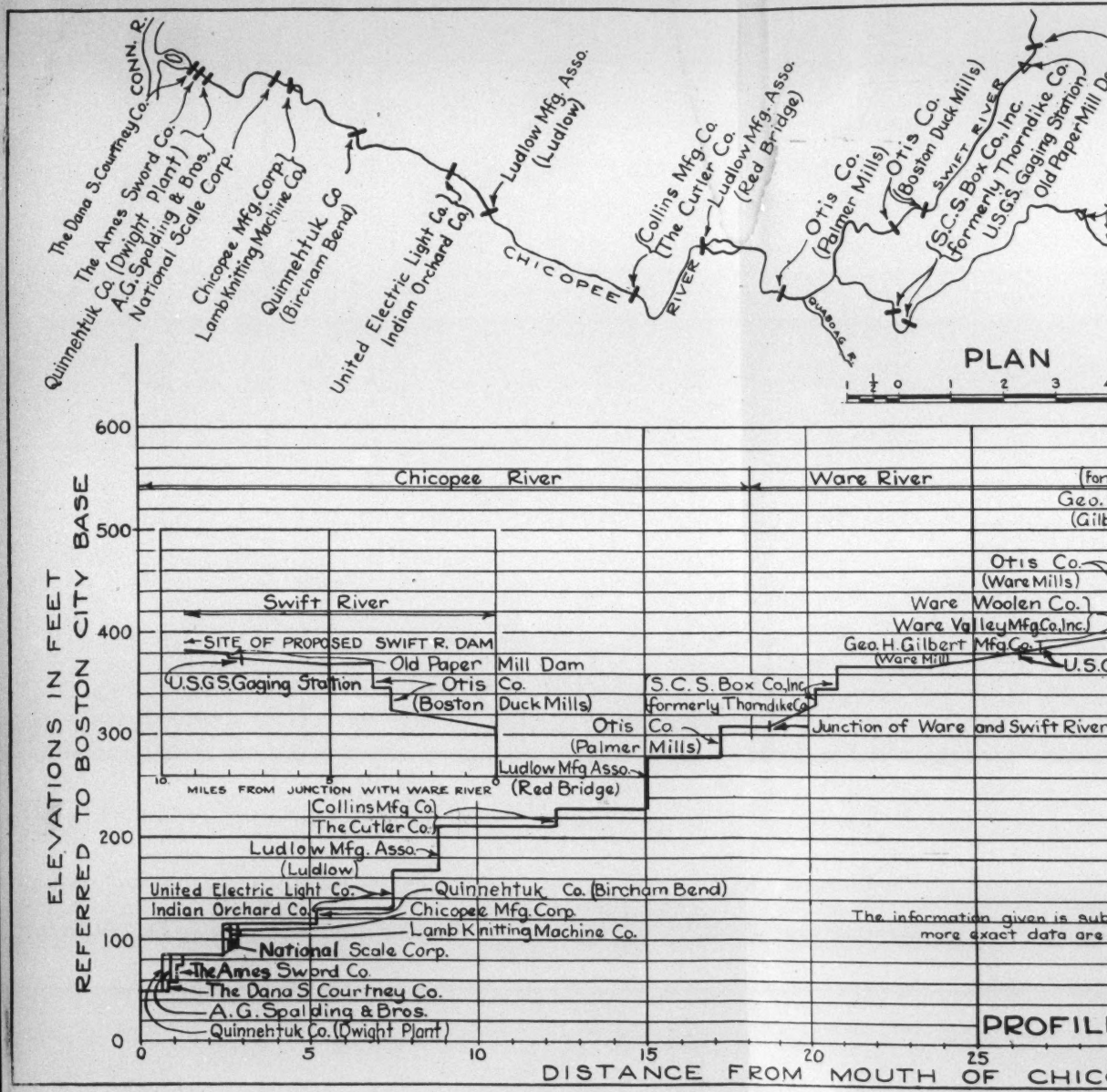
Figure 3 shows the locations of the various plants affected by diversions, the existing dams, the fall developed at each and the installed water-power equipment as of June, 1935. Subsequently, some of the dams have been carried away and not replaced, and there have been some changes in hydraulic machinery. The table, however, gives a fair picture of the magnitude of the task of settling all the claims for diversion damages.

Riparian owners of the Ware River were affected by the Ware diversion only; those on the Swift River (there was only one) by the Swift diversion only; and those on the Chicopee River by both Ware and Swift diversions, as was also the plant (not shown or listed in Figure 3) of the Northern Connecticut Power Co. at Windsor Locks on the Connecticut River.

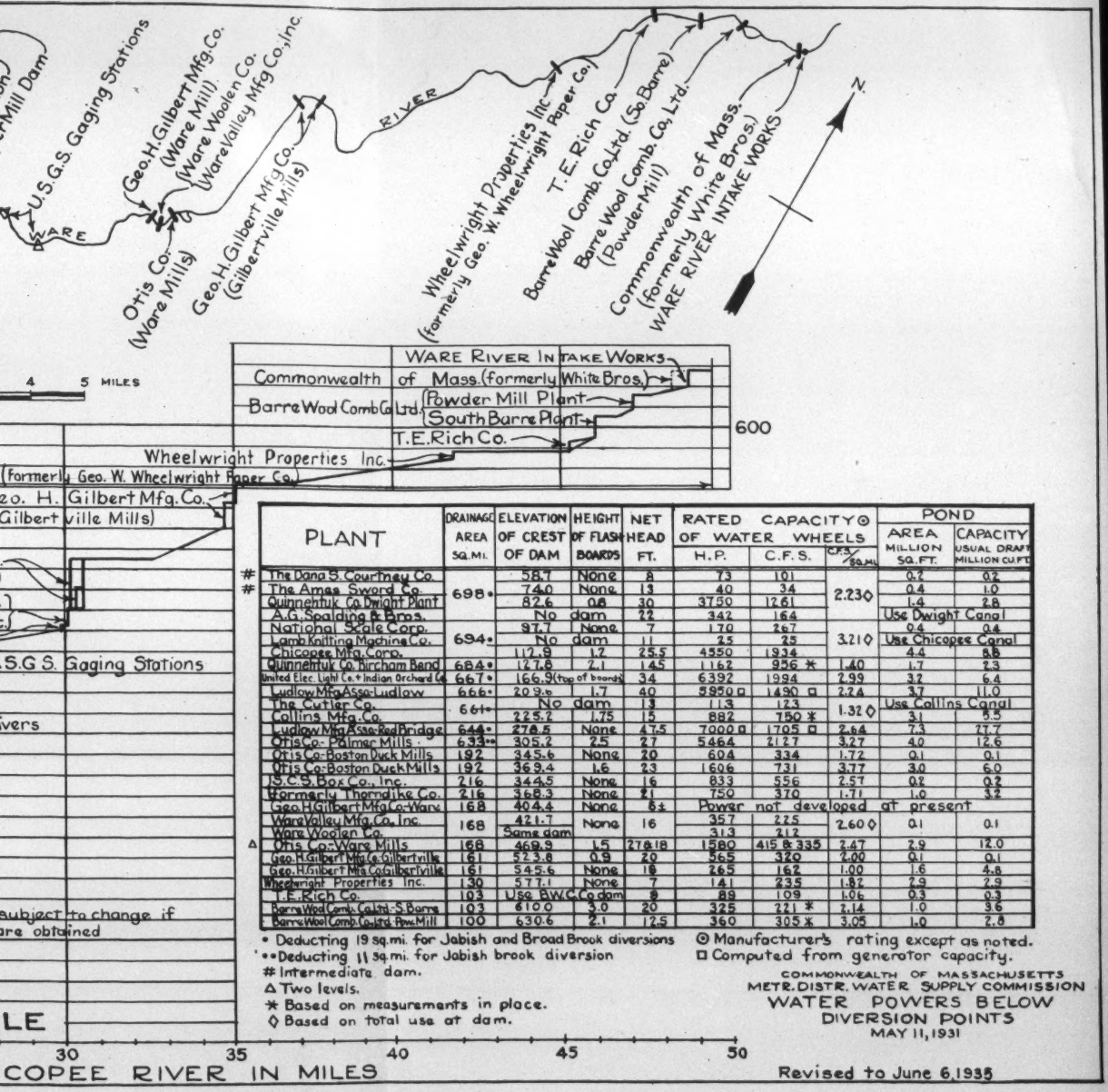
The Swift River Act empowered the Commission to settle Swift diversion damage claims by agreement in advance of actual diversion. Suits could not be filed under this act or the Ware River Act until after actual diversion.

Under this authorization, negotiations for the settlement by agreement of many cases got under way shortly after the Ware diversion and by late 1933 several agreements had been reached, payments had been made in some cases and satisfactory progress was being made in others. But in 1933, the George H. Gilbert Manufacturing Co., with two plants in Gilbertville and one in Ware—all three on the Ware River—was sold and the new owners proceeded to sue.

This case came to trial on November 20, 1933, in Hampshire County Superior Court at Northampton, Mass., and lasted nearly seven weeks. On January 4, 1934, the jury brought in an award of $305,708.33, of which $259,852.08 applied to the mills at Gilbertville, which is in Worcester County, and $45,856.25 to the mill at Ware, which is in Hampshire County. The fact that the properties lie in different counties necessitated two petitions and separate awards, but both cases were tried together in Hampshire. The Hampshire verdict was set aside and a new trial was ordered but, rather


The Dana S. Courtney Co.
CONN. R.
The Ames Sword Co.
Quinnehtuk Co. (Dwight Plant)
A.G. Spalding & Bros.
National Scale Corp.
Chicopee Mfg. Corp.
Lamb Knitting Machine Co.
Quinnehtuk Co. (Bircham Bend)
United Electric Light Co.
Indian Orchard Co.
Ludlow Mfg. Asso. (Ludlow)
CHICOPEE RIVER
Collins Mfg. Co.
The Cutler Co.
Ludlow Mfg. Asso. (Red Bridge)
Otis Co. (Palmer Mills)
Otis Co. (Boston Duck Mills)
SWIFT RIVER
S.C.S. Box Co., Inc. formerly Thorndike Co.
U.S.G.S. Gaging Station
Old Paper Mill Dam
PLAN
ELEVATIONS IN FEET REFERRED TO BOSTON CITY BASE
600
500
400
300
200
100
0
Chicopee River
Ware River
Swift River
SITE OF PROPOSED SWIFT R. DAM
Old Paper Mill Dam
U.S.G.S. Gaging Station
Otis Co. (Boston Duck Mills)
S.C.S. Box Co., Inc. formerly Thorndike Co.
Otis Co. (Palmer Mills)
Junction of Ware and Swift River
Ludlow Mfg. Asso. (Red Bridge)
MILES FROM JUNCTION WITH WARE RIVER
Collins Mfg. Co.
The Cutler Co.
Ludlow Mfg. Asso. (Ludlow)
United Electric Light Co.
Indian Orchard Co.
Quinnehtuk Co. (Bircham Bend)
Chicopee Mfg. Corp.
Lamb Knitting Machine Co.
National Scale Corp.
The Ames Sword Co.
The Dana S. Courtney Co.
A. G. Spalding & Bros.
Quinnehtuk Co. (Dwight Plant)
Otis Co. (Ware Mills)
Ware Woolen Co.
Ware Valley Mfg. Co., Inc.
Geo. H. Gilbert Mfg. Co. (Ware Mill)
The information given is sub
more exact data are
PROFIL
0
5
10
15
20
25
DISTANCE FROM MOUTH OF CHIC

FIG



PLANT	DRAINAGE AREA SQ. MI.	ELEVATION OF CREST OF DAM	HEIGHT OF FLASH BOARDS	NET HEAD FT.	RATED CAPACITY ⊙ OF WATER WHEELS H.P.	C.F.S.	C.F.S./SQ.MI.	POND AREA MILLION SQ.FT.	POND CAPACITY USUAL DRAFT MILLION CU.FT.
# The Dana S. Courtney Co.	698•	58.7	None	8	73	101	2.230◊	0.2	0.2
# The Amos Sword Co.		74.0	None	13	40	34		0.4	1.0
Quinnehtuk Co Dwight Plant		82.6	0.8	30	3750	1261		1.4	2.8
A.G. Spalding & Bros.		No dam		22	342	164		Use Dwight Canal	
National Scale Corp.	694•	97.7	None	7	170	267	3.210◊	0.4	0.4
Lamb Knitting Machine Co.		No dam		11	25	25		Use Chicopee Canal	
Chicopee Mfg. Corp.		112.9	1.2	25.5	4550	1934		4.4	8.8
Quinnehtuk Co. Burcham Bend	684•	127.8	2.1	145	1162	956 *	1.40	1.7	2.3
United Elec. Light Co. + Indian Orchard Co.	667•	166.9 (top of boards)		34	6392	1994	2.99	3.2	6.4
Ludlow Mfg Asso. Ludlow	666•	209.6	1.7	40	5950 □	1490 □	2.24	3.7	11.0
The Cutler Co.	661•	No dam		13	113	123	1.320◊	Use Collins Canal	
Collins Mfg. Co.		225.2	1.75	15	882	750 *		3.1	5.5
Ludlow Mfg Asso. Red Bridge	644•	278.5	None	47.5	7000 □	1705 □	2.64	7.3	27.7
Otis Co. Palmer Mills	633••	305.2	2.5	27	5464	2127	3.27	4.0	12.6
Otis Co. Boston Duck Mills	192	345.6	None	20	604	334	1.72	0.1	0.1
Otis Co. Boston Duck Mills	192	369.4	1.6	23	1606	731	3.77	3.0	6.0
J.S.C.S. Box Co., Inc.	216	344.5	None	16	833	556	2.57	0.2	0.2
Formerly Thorndike Co.	216	368.3	None	21	750	370	1.71	1.0	3.2
Geo. H. Gilbert Mfg. Co. Ware	168	404.4	None	6±	Power not developed at present				
Ware Valley Mfg. Co., Inc.	168	421.7	None	16	357	225	2.60◊	0.1	0.1
Ware Woolen Co.		Same dam			313	212			
△ Otis Co. Ware Mills	168	469.9	1.5	27&18	1580	415 & 335	2.47	2.9	12.0
Geo. H. Gilbert Mfg. Co. Gilbertville	161	523.8	0.9	20	565	320	2.00	0.1	0.1
Geo. H. Gilbert Mfg. Co. Gilbertville	161	545.6	None	18	265	162	1.00	1.6	4.8
Wheelwright Properties Inc.	130	577.1	None	7	141	235	1.82	2.9	2.9
T.E. Rich Co.	103	Use BWC Co dam		8	89	109	1.06	0.3	0.3
Barre Wool Comb. Co. Ltd. S. Barre	103	610.0	3.0	20	325	221 *	2.14	1.0	3.6
Barre Wool Comb. Co. Ltd. Pow. Mill	100	630.6	2.1	12.5	360	305 *	3.05	1.0	2.8

• Deducting 19 sq. mi. for Jabish and Broad Brook diversions
••Deducting 11 sq. mi. for Jabish brook diversion
Intermediate dam.
△ Two levels.
* Based on measurements in place.
◊ Based on total use at dam.

⊙ Manufacturer's rating except as noted.
□ Computed from generator capacity.

COMMONWEALTH OF MASSACHUSETTS
METR. DISTR. WATER SUPPLY COMMISSION
WATER POWERS BELOW DIVERSION POINTS
MAY 11, 1931

Revised to June 6, 1935

FIG. 3.

than retry, the petitioner accepted $260,000 as full compensation. This was a lot of money, especially as compared with the settlements which had been made by agreement, and thereafter most negotiations stopped and the remaining cases were tried.

Little was said in the negotiations for amicable settlement about damage other than that to developed and undeveloped water power. The Commission's consultants in estimating damages for the guidance of the Commission in its negotiations with riparian owners were liberal in their estimates of water-power damage, having in mind that damage of that type might not be the sole damage. Recognizing that pollution damage claims might be pressed—that is, claims that diversion would impair the quality of the river water, which was used by many of the mills for process purposes and boiler feed, and would also reduce the volume available for the disposal of manufacturing wastes—the engineers and chemists of the Commission made extensive and generally continuous tests to determine the quality of water in the Ware, Swift and Chicopee, both above and below the manufacturing plants of the various riparian owners. These analyses and studies had been in progress for two or three years prior to the trial of the Gilbert case and regular weekly sampling at pertinent points was continued until the conclusion of the last of the cases.

In addition to the continuous sampling above and below the mills, many special tests and studies were made. Twenty-four-hour tests were made at each principal plant and in some cases over a stretch of river covering several plants, in which samples of river water were taken at hourly intervals and a continuous record of the stream flow was obtained simultaneously, usually by special gaging stations established for the purpose, in order to determine the actual quantities of the various constituents carried by the stream.

Since the pollution damages, if any, on the Ware River would be caused by the reduction of the spring scouring flows by the diversion of the "flood waters" at Coldbrook with resulting accumulation of organic deposits in the pools and ponds, a comprehensive test to determine the extent of such scouring action was planned. The opportunity for this test came in September, 1933, when heavy rains over the entire watershed caused a rapid and very considerable rise in all the tributaries and the main stream. No diversions were made

at Coldbrook during the test, as it came within the period in which the War Department restriction does not permit diversion. Measurements of flow were made at Coldbrook, as well as at points on the river below Coldbrook and on the principal tributary streams below Coldbrook. Water samples were taken at frequent and periodic intervals and analyzed for determination of suspended matter, both organic and inorganic. The observations were continued for about five days, commencing a few hours before the flow rise began and continuing until a reasonably constant regimen was established.

Tests were made to determine the time of transit of water in the Ware River by the dumping of salt into the stream and observing, by analysis, the time of its appearance at points downstream. Tests were also made, in coöperation with the owner, of industrial wastes as discharged into the river at some of the plants.

A complete list of all the special observations, tests and studies made would require much space and much time to prepare, and its value today would not warrant the labor, if indeed the data could be assembled at this late day. Most of the work was done 10 to 20 years ago.

There was not, in any of the cases, any great difference between the estimates of power which could be developed either before or after diversion made by the petitioners' engineers and those made by the engineers of the Commission. Experts on both sides used the same fundamental data, which were complete and not controversial. The power damage estimates, expressed in dollars, however, were naturally divergent, depending upon the assumptions made as to such factors as hours of mill operation, possible increased load through mill expansion, potential undeveloped power and rate of capitalization of annual losses as estimated under the conditions assumed. In general, however, such divergencies were not difficult to compromise in negotiations and were probably understood by the jury in cases tried.

Pollution damage claims, on the other hand, were different. These, in general, were denied by the Commonwealth. As has been noted, except in one or two cases, damages of this nature were not given specific consideration in the negotiation of settlements by agreement. Also, in the cases of plants on the Chicopee River which were tried, there was no claim advanced for pollution damages. But in

the Ware and Swift River trials such damages constituted the bulk of the petitioners' claims.

This paper, while giving much space to consideration of pollution damage claims, does not go into equal detail with respect to water-power damages. This is because the settlement and trial of water-power damage cases is an old story and all such cases necessarily follow the same general line of reasoning, whereas pollution damage claims are comparatively new and, in the cases reported here, dealt not with established physical conditions, but with the prediction of what effect diversions might have in the future upon the quality of water, with respect to its adaptability for industrial use, and upon the ability of the stream to receive and satisfactorily dispose of industrial wastes after diversion. The door was open to the imagination and the opportunity to exercise it was fully utilized by the petitioners' experts.

Exceptions to the above remarks regarding water-power damages are the Ludlow Manufacturing Associates cases, both the Ware and the Swift cases. The hydro plants of this company with a total head of 89 ft, subjected to both diversions, constituted a potential damage far in excess of any other water power affected by diversions and there were other unusual conditions, which seemed to warrant more thorough reporting than in other cases. Furthermore, the Ludlow-Swift diversion case was carried to the Supreme Court on exceptions, some of which were sustained, and a second trial was necessary.

Before considering individual claims, which will be divided into those settled by agreement and those tried, brief consideration should be given to conditions on the Ware and Swift Rivers and the manner in which the mills might be affected by diversion.

All the mills on the Ware River, except that of the Gilbert Co. at Ware, had developed water powers when diversion occurred in 1931. Since, under the law, the flow at Coldbrook may not be reduced by diversion below 85 mgd or 131 cfs, there is no reduction in flow or water power available during a considerable portion of the time. Actually, the long-term record shows that diversions may occur only about 40% of the time, the flow at Coldbrook being less than 85 mgd about 60% of the time. Furthermore, the percentage of flow which is diverted decreases progressively downstream from Coldbrook, since

each plant receives the run-off from the drainage area between Coldbrook and that plant undiminished.

Since the lower flows of the Ware River—those occurring for 60% of the time—are not altered by diversion, any effect upon the quality of the water chargeable to diversion could come only from a reduction of freshet flows and the petitioners' experts made the claim, in those cases which were tried, that the reduction in the freshet flows would reduce the scouring effect of such flows, with the result that there would be increased deposits of organic materials left in the stream at the beginning of each summer, which deposits would decompose in the hot weather, impair the quality of the water and reduce or destroy its ability to receive and dispose of manufacturing wastes without nuisance

On the Swift River there is only one mill below the diversion point, Winsor Dam, that of the Boston Duck Co. With over 90% of its water taken away it had, of course, a substantial, justifiable claim for water-power damage. Claims for pollution damage were highly controversial. With more than sufficient water remaining (20 mgd) for process use, a claim for process-water damage hinged upon the effect of impounding the water at Winsor Dam on its quality. A claim for waste-disposal damage hinged upon the question whether the post-diversion flow of 20 mgd would be sufficient to keep the stream in as good condition as under pre-diversion conditions.

Cases Settled by Agreement

The Swift River Act authorized the Commission to make settlements of Swift River diversion damage claims in advance of actual diversion and to make contracts, subject to the approval of the governor and council, binding upon the Commonwealth and upon owners of riparian rights with whom such agreements were reached. The Ware River Act made no provision for such advance settlement. Both acts provided that petitions for the assessment of damages might be filed within two years after, and not before, the actual diversion. It was, of course, permissible to settle Ware River diversion damage claims by agreement after actual diversion, which occurred March 20, 1931.

The usual course of procedure was for the Commission to receive

reports and advice as to settlement from its staff and consultants and, armed with this background, to sit down with representatives of the owner and proceed to negotiate.

Table 1 records all settlements reached by agreement, arranged in the order of the dates on which payments were made. This does not represent the exact order in which the agreements were reached. Many of the negotiations were carried on simultaneously and the time required to draw up and obtain approval of the contracts varied.

The Dwight Manufacturing Company

This company owned and operated a cotton mill near the mouth of the Chicopee River. Appurtenant to the mill property was a hydro-electric power plant. The water-power development consisted of a dam with a canal leading to the hydro plant, from which A. G. Spalding & Bros. had the right to draw up to 100 cfs under certain conditions. Below the Dwight dam were two intermediate dams, both by-passed by the Dwight hydro plant—that is, the water discharged by the Dwight hydro plant entered the river below the lower of these dams. The discharge from the Spalding wheels was between the two intermediate dams. The owner of the upper intermediate dam, the Ames Sword Co., thus received only water which came over the Dwight dam, and the owner of the lower intermediate dam, the Dana S. Courtney Co., received only that water plus the discharge from the Spalding wheels. Separate settlements were made with the Spalding, Ames and Courtney companies subsequent to the Dwight settlement, as shown in Table 1 and reported hereinafter.

The Dwight development contained wheels with an aggregate capacity of 3,750 hp, using 1,261 cfs of water at 30 ft head. The net drainage area is 698 sq mi.

By mutual agreement, Charles T. Main was chosen to investigate and report to both the company and the Commission his opinion as to the damage to be caused by the Ware diversion and the then future Swift diversion. He recommended settlement at $275,000. The amount finally agreed upon was $225,000.

Not long after the settlement the Dwight development was sold to Quinnehtuk Co. for public-utility use.

TABLE 1.—DIVERSION DAMAGE CASES SETTLED BY AGREEMENT

Company	Located on	Diversion covered (W=Ware; S=Swift)	Amount paid	Date of payment	Estimate of Commission's engineers	Claim of owners
Dwight Mfg. Corp.	Chicopee	W & S	$225,000	12/3/31	$275,000	$275,000
Thorndike Co.	Ware	W	25,000	4/28/32	32,500	172,500
Geo. W. Wheelwright Paper Co.	Ware	W	35,000	5/24/33	18,000	75,000
T. E. Rich Co.	Ware	W	3,250	6/26/33	5,000	5,000
Quinnehtuk Co.	Chicopee	W & S	140,000	7/12/33	135,000	153,000
A. G. Spalding & Bros.	Chicopee	W & S	12,000	8/9/33	12,000	12,000
Chicopee Mfg. Corp.	Chicopee	W & S	250,000	8/10/33	300,000	375,000
Ames Sword Co.	Chicopee	W & S	2,500	2/7/34	7,000	15,000
Dana S. Courtney Co.	Chicopee	W & S	10,000	5/9/34	8,500	16,000
Northern Conn. Power Co.	Conn.	W & S	30,000	8/1/34	20,000	201,000
Indian Orchard Co.	Chicopee	W & S	375,000	9/28/34	393,600	425,000
Collins Mfg. Co.	Chicopee	W & S	314,083	12/10/37	360,000	800,000
The Cutler Co.	Chicopee	W & S	15,000	3/19/40	16,000	35,000
Total			$1,436,833			

The Thorndike Company

The property involved in this settlement consisted of two mill plants, each with a water-power development consisting of a dam, a canal and water wheels. At the time of the negotiations these properties were no longer owned by the Thorndike Co., but the deed of sale had reserved to the Thorndike Co. the right to future diversion damages.

The mills are located on the Ware River, two to three miles above the mouth of the Swift. They were built and operated as cotton mills by the Thorndike Co. The upper privilege had 750 hp of wheels using 370 cfs at 21 ft head. The lower privilege was equipped with 833 hp of wheels requiring 556 cfs of water at 16 ft head. The drainage area is substantially the same at both plants—216 sq mi.

An unsuccessful attempt was made by engineers of the owner and the Commission to agree upon a figure to recommend for a settlement. The figures were far apart—$172,500 claimed by the owner's consultant; $32,500 by the Commission's engineers. Settlement was effected at $25,000. The engineers' estimates were based solely on water-power damage. No consideration was given to pollution damages.

George W. Wheelwright Paper Company

This company owned and operated a paper mill on the Ware River at the village of Wheelwright in Hardwick. There is an appurtenant water power, rated at 141 hp at 7 ft head and 235 cfs water use. The drainage area is 130 sq mi. The owners asked $75,000; the Commission's engineers recommended $18,000 as fair; settlement was at $35,000. Water-power damage only was considered.

T. E. Rich Company

This company owned and operated a small wood-working mill at Barre Plains. It had a single water wheel, rated at 89 hp at 9 ft head and 109 cfs. A small pond acted as a forebay. This pond received only water discharged by the wheels of the lower hydro plant of the Barre Wool Combing Co. at South Barre, through a long canal. The settlement was $3,250. The owner asked $5,000.

Quinnehtuk Company

This company, a subsidiary of Western Massachusetts Companies, owned and operated a hydro-electric plant on the Chicopee River at Bircham Bend, supplying electricity to the United Electric Light Co. of Springfield, also a subsidiary of Western Massachusetts Companies. Its hydraulic equipment consisted of 1,162 hp of wheels, using 956 cfs of water at a net head of 14.5 ft. The net drainage area was 684 sq mi. The owner claimed a damage of $153,000. The Commission's engineers estimated $135,000. The settlement was at $140,000.

This development was subsequently swept away by flood and was never rebuilt.

A. G. Spalding and Brothers

This company owned and operated a plant making sporting goods, located on the Chicopee River at Chicopee between the Dwight Canal and the river. It owned rights in the canal to draw under certain conditions a maximum of 100 cfs, and it had and used two waterwheel installations. These units were rated as follows: unit number 1—114 hp when discharging 55 cfs under 22 ft head; and unit number 2—228 hp when discharging 109 cfs under 22 ft head.

By mutual agreement, Charles T. Main reported to both the company and the Commonwealth his opinion of a fair award for the damages, as of June 1, 1933. His figure was $12,000 and was accepted by both parties.

Chicopee Manufacturing Corporation

The Chicopee Manufacturing Corp. owned a water power on the Chicopee River at Chicopee Falls, which it used to operate cotton textile mills. The net drainage area at this point is 694 sq mi, after deducting 19 sq mi on Jabish and Broad Brooks taken by the city of Springfield for water supply. The total gross head is about 30.7 ft but, owing to certain existing conditions, the average net effective head was only 25 ft. Based on this head, the development had a total rated capacity of 4,414 hp, with 2,450 kw of generator capacity using 1,917 cfs of water, and comprised 5 separate wheel installations in scattered locations. Redevelopment of the privilege in

one location to a capacity of 2,082 cfs, with an average net effective head of 27 ft producing 4,000 kw, was considered economically feasible by the Commission's consultant.

This consultant reported to the Commission his estimates of damages upon various assumptions of mill load, considering both the existing hydro plant and a redevelopment. These estimates, which were as of the date of diversion, ran from $33,800 to $34,900 for the Ware diversion and from $349,400 to $417,200 for the Swift diversion. He concluded that the Ware damage was $34,000 and the Swift damage not over $420,000, both as of the dates of diversion. Subsequently he reported that, in his opinion, $300,000 would be a fair settlement. He also estimated the damage on the basis of utilization for public-utility purposes, assuming redevelopment 5 years in the future (i.e. in 1938, the report being made in 1933), and found present (1933) values of the estimated damages as follows:

Ware diversion	$ 36,760
Swift diversion	210,560
Total	$247,320

Settlement was made at $250,000.

Ames Sword Company

This company owned a small (40-hp) water-power plant and dam, located just below the Dwight dam on the Chicopee River. The Quinnehtuk Co. (successor to the Dwight Manufacturing Co.) and A. G. Spalding & Bros. owned all rights to water approaching the Dwight dam and the Ames Sword Co. had no definite water rights. It had, however, used leakage and waste over the Dwight dam for many years, and might thereby have acquired prescriptive rights.

On the assumption that such rights had been acquired, the consultant to the Commission reported estimated damages due to diversion, as of the dates of diversion, as follows:

Ware diversion	$1,000
Swift diversion	6,000
Total	$7,000

The consultant added, however, "There seems to be no assurance that there is a legal right to any damages whatever".

Settlement was effected at $2,500.

Dana S. Courtney Company

Dana S. Courtney Co. owned the lower of two dams intermediate between the Dwight dam and the tailrace of the Quinnehtuk Co. (successor to the Dwight Manufacturing Corp.) on the Chicopee River, together with a small (70-kw) hydro plant, formerly used to drive the bobbin factory of the company but, at the time of the settlement, out of repair and unused. The rights to all water approaching the Dwight dam were owned by the Quinnehtuk Co. and A. G. Spalding & Bros. The Courtney privilege received the discharge from the Spalding wheels and the leakage and spill from the Dwight dam after passing the Ames Sword dam.

The Commission's consultant advised that redevelopment of the Courtney privilege at 180 hp was economically feasible and concluded that a fair settlement for the possible future damage due to diversion, on the assumption of redevelopment to that capacity, would be on the basis of the following amounts, as of the dates of diversion:

Ware diversion	$1,000
Swift diversion	7,500
Total	$8,500

The owner asked $16,000. Settlement was at $10,000.

Northern Connecticut Power Company

This company owned property on the Connecticut River at Windsor Locks, Conn., consisting of an old timber-crib dam, diverting a portion of the flow of the Connecticut River through a small navigation canal around the Enfield (Conn.) rapids, and certain mill properties, holding perpetual leases for the use of water from the canal for power purposes.

The Commission's consultant and adviser on water-power damage settlements, the late Charles T. Main, reported that the maximum quantity which the Windsor Locks canal could carry under the exist-

ing conditions was less than the low flow of the Connecticut River either before or after diversion; that under existing conditions no measurable decrease in the canal capacity or available head would result from the diversion, and since the leased rights of the mills were less than the maximum carrying capacity of the canal for power purposes, no damage would be sustained by the mills.

However, he considered that a redevelopment of the entire project, to develop 48,000 kva in a manner such as had already been studied, might at some future time be made. If so, there would be a reduction in value resulting from the diversions which, if redevelopment were immediate, would amount to $40,500. He advised that, in his opinion, $20,000 would be "a sufficient amount to offer for the settlement of all possible future damage". The owner asked $201,000. The amount agreed upon and paid was $30,000.

Indian Orchard Company

The Indian Orchard privilege is located on the Chicopee River about 5 miles above its mouth. The net drainage area, after deducting the city of Springfield takings on Jabish and Broad Brooks, is 667 sq mi. The average net effective head was 33 ft.

The privilege was originally developed by the Indian Orchard Co. and the power generated was used to drive a cotton mill. At the time of the Ware taking, however, the water-power property, including all water rights, was under lease to the United Electric Light Co. of Springfield for a term of 30 years, expiring in 1958. The land, dam, canal and the water rights belonged to the Indian Orchard Co. The United Electric Light Co. owned the power plant and equipment which it operated. The power generated was used for public-utility purposes in the system of the Western Massachusetts Companies, of which the United Electric Light Co. was a subsidiary.

The total rated capacity at 33 ft head of the Indian Orchard hydroelectric plant, at that time, was 4,900 kw, in four units: two at 600, one at 1,500 and one at 2,200 kw. The water capacity of the four units was 2,132 cfs.

The Commission's consultant estimated the damages as of the dates of diversion by evaluating the kilowatt-hours lost by each diversion in an average year and capitalizing the annual losses thus esti-

mated at 5%. In evaluating the lost power he separated it into day power (2,400 hours per year), upon which he placed a value of $0.005, night power (5,360 hours) at $0.004 and Sunday-holiday power (1,000 hours) at $0.002.

He thus obtained estimated damages, as of the dates of diversion, of:

Ware diversion	$ 41,085
Swift diversion	306,060
Total	$347,145

The present (1933) values of these figures, using 5% compound interest and discount rates [the Swift diversion was assumed to occur 7 years in the future], he found to be:

Ware diversion	$ 45,300
Swift diversion	217,500
Total estimated water-power damages	$262,800

Subsequently, in April, 1934, the Commission directed its consultant to confer with the company's engineering adviser, with a view to agreeing upon the kilowatt-hours diverted and the unit value of same. The engineers reached an agreement on the power diverted, 4,500,000 kwh, but did not agree upon the price, the Commission's engineer claiming $0.005 per kilowatt-hour to be a proper price and the company's engineer claiming $0.006.

The Commission was then advised by its consultant that his estimates, based on the agreeed lost power and $0.005 per kilowatt-hour, amounted to $357,900 and to $393,600 if based on $0.0055 per kilowatt-hour, both figures being present value.

Settlement was effected at $375,000.

Collins Manufacturing Company

This company owned and operated a paper mill with appurtenant water power on the Chicopee River at North Wilbraham. Included in its property were riparian rights in the Chicopee River and a developed water power, used to drive the mill. The company also used the river for manufacturing purposes.

The water-power privilege had a net drainage area of 661 sq mi after deducting 19 sq mi taken by the city of Springfield for water-supply purposes. The head was about 15 ft. The development consisted of two units with a combined capacity of 882 hp, requiring 745 cfs at 13 ft head. Cutler Co., which owned a grist mill and elevator, located just below the Collins mill, had the right to use sufficient water to furnish 100 hp for 12 hours each day, subject to certain reservations.

In 1933 negotiations for a settlement of the Ware and Swift diversion damages commenced. The Commission's consultant reported minimum and maximum estimated water-power damages of $188,350 and $248,340 respectively, both figures as of the dates of diversion, but concluded "that a reasonable present (1933) value of possible redevelopment and increase in load, and including the damage for present conditions of plant, lies within the following limits":

	Maximum	Minimum
Total damages due to Ware diversion	$ 19,800	$ 10,400
Total damages due to Swift diversion	164,100	127,300
Total	$183,900	$137,700

Subsequently, this consultant was authorized by the Commission to confer with engineers representing the Collins Manufacturing Co., with a view to reaching an agreement as to the amount of water power diverted and the unit value thereof. The engineers did reach such an agreement and, under date of December 3, 1934, the Commission was advised that the water-power damages, based upon the agreed figures of power lost and price, amounted to $260,400 as of the dates of diversion.

During the year 1934 the attorney and engineers representing the Collins Manufacturing Co. had several conferences with the Commission in which claims for pollution damages were made. As a result, the late Frank A. Barbour, honorary member of this Association, was asked to investigate and report to the Commission on the damage due to reduced flow of the river, as affecting its capacity to dispose of the industrial wastes of the Collins Manufacturing Co. and its suitability for use for manufacturing purposes. Under date of Febru-

ary 26, 1935, he gave an opinion that the company would be able to recover damages of $75,000 to $100,000 and possibly more for treatment of industrial wastes.

The Commission was thus advised that a settlement, based upon the agreed figures for power lost and the unit price thereof and upon Mr. Barbour's minimum and maximum figures for waste disposal, would be between $335,000 and $360,000, both as of dates of diversion.

The Collins Manufacturing Co. made a maximum claim of $800,000, covering water-power and pollution damages. During the negotiations this amount was reduced to $600,000 and finally to $450,000.

On June 3, 1935, the company made a formal offer to accept $300,000 in full settlement of all claims and on June 4, 1935, the Commission voted to accept it. In July, 1935, a satisfactory deed and release, duly executed, was received by the Commission, approved by the Attorney General as to form and duly recorded in the Registry of Deeds, Hampden County, and a schedule for the payment of $300,000 to the Collins Manufacturing Co. was approved by the Commission and forwarded to the Comptroller.

This, however, was not the end of the case. The Swift River Act, which authorized the Commission to make settlements in advance of diversion, requires that contracts binding such settlements be approved by the governor and council. On September 25, 1935, the council refused to approve the agreement. The matter then lay dormant until November, 1937. Payment of $314,000 was approved by the executive council December 2, 1937, by an 8-to-1 vote. The increase of $14,000 above the amount originally agreed upon represented interest at 2% from July 21, 1935, to December 1, 1937.

The story of the negotiations and settlement of this case has been reported here in detail, because it attracted considerable attention and adverse criticism at the time the settlement was made. The price was proportionately much higher than was paid in the Dwight, Chicopee Manufacturing, Bircham Bend (Quinnehtuk) and Indian Orchard settlements. Those settlements, reduced to values of the date of payment of the Collins settlement—December 10, 1937—on a per-

square-mile-of-drainage-area-diverted*-per-foot-head basis, ranged from about $55 to $64 per square mile diverted per foot head and averaged about $59. The Collins settlement on this basis amounted to about $105. The higher price paid was due largely, but not entirely, to consideration of the pollution damage claim.

The Cutler Company

The Cutler Co., a subsidiary of the New England Grain Co., owned a grist mill and grain elevator on the Chicopee River at North Wilbraham, located adjacent to, and downstream from, the mill of the Collins Manufacturing Co. The Cutler Co. under a long-term lease, expiring in 1976, had the right to draw, with certain reservations, from the Collins canal "so much water as shall be sufficient to furnish one hundred horsepower for twelve hours each day", for which right an annual payment of $1,000 was made. Milling operations at this plant had been abandoned prior to the Ware diversion.

The Commission's consultant reported that, in his opinion, no damage resulted from the Ware diversion and that the Swift diversion damage (as of June, 1932), as he estimated it on different assumptions of possible future use, including replacement of the existing water wheel with a new wheel of higher efficiency, ranged from $4,550 to $15,310. Based on actual running conditions when the mill had last operated, his figure was $10,000.

Settlement, made in 1940, amounted to $15,000.

Barre Falls Reservoir Company

This company, the stock of which was owned by several of the mills on the Ware River, owned or controlled a number of storage reservoirs on the watershed of the Ware River above Coldbrook, which it operated to augment the river flows during low-water periods. It also owned a large undeveloped reservoir site at Barre Falls.

The case came up for trial in Hampshire County. A jury was impaneled and started on the "view", but during luncheon in Ware an agreement for settlement was effected between counsel for the petitioner and for the Commonwealth, and the trial was called off then and there.

*The drainage areas diverted have been taken as: Ware, 25 sq mi; Swift, 175 sq mi; total, 200 sq mi.

Under this agreement the Commonwealth acquired all water rights owned by the petitioner and certain real estate, the petitioner receiving $4,800 on December 5, 1936. The company had claimed $7,500 for damages only. This case does not appear in Table 1, since the settlement included the transfer of real estate.

Cases Tried

Table 2 records the amount of the verdict in each of the cases tried; the damage claimed by the petitioner, and the cost to the Commonwealth of trying the case. The figures giving the petitioners' claims have been compiled from the transcript of the evidence as representative, although many other figures appear in the testimony. The trial costs are actual, but do not include engineering and clerical salaries of the Commission's staff.

Before proceeding with a discussion of each of the individual cases tried, it seems advisable to consider some of those factors or elements applicable to all or many of the cases.

First as to the law of waters. An excellent presentation of this subject was given by Charles F. Choate, Jr., before this association in a paper entitled "The Underlying Principles Governing Riparian Water Rights and Diversion Suits", published in the Journal of March, 1910, Volume 24. Reference to it should prove helpful to any layman concerned with water rights. Briefly, a riparian owner is one owning property on the bank of a stream. Each riparian owner is entitled to use the water as he sees fit, but must pass it along to lower riparian owners undiminished in volume and unimpaired in quality. Over the years the courts have interpreted this requirement rather broadly, so that actually a reasonable amount of water may be used for the watering of stock and for domestic and other purposes, and a reasonable amount of pollution may be added, but not to such an extent that the water is rendered unfit for use by lower riparian owners. If a riparian owner does unreasonably pollute, he is subject to court action by lower riparian owners. Apparently, the right to pollute may be acquired by prescription—witness the following from the judge's charge: "Now, the Otis Company is entitled to keep on dumping that quantity of effluent into the stream that it did before diversion ever came".

TABLE 2.—DIVERSION DAMAGE CASES SETTLED BY LITIGATION

Company	Date verdict returned	Amount of verdict (cents omitted)	Claim of petitioner	Expense of trial to Commonwealth (cents omitted)
Geo. H. Gilbert Mfg. Co.	1/4/34	$305,708*	$1,110,000	$ 29,757
Barre Wool Comb. Co.	7/20/35	189,304	807,100	16,643
Ware Woolen Co.	1/30/36	88,786	280,800	29,307
Otis Co.	4/17/36	192,397	296,200	38,391
Ware Valley Mfg. Co.	6/17/36	17,765	75,000	13,912
Arthur W. Holbrook	7/24/36	9,660	63,000	13,529
Ludlow Mfg. Assoc.—Ware Diversion Case	12/22/36	52,275	83,000	41,041
National Scale Co.	1/15/37	0	10,960	4,456
Boston Duck Co.	4/12/40	62,267†	1,000,000	102,255
Palmer Mills, Inc.	10/17/41	84,747	223,000	12,782
Ludlow Co.—Swift Diversion				
1st trial	12/14/44	239,582	822,000	64,318
2nd trial	5/13/48	315,000	822,000	34,053
Total (exclusive of 1st trial of Ludlow Co.—Swift Diversion)		$1,317,909		

*Final settlement by agreement, $260,000.
†Final settlement by agreement, $88,423.

Secondly, as to the damage for which, under the law, the Commonwealth is liable in these diversion cases. Water rights are appurtenant to the land. Under the law the damage is not the cost of placing the owner in the same position post-diversion as he was before diversion, by giving him a sum which will pay for any necessary construction and provide enough more which, if placed at interest, will provide annually, ad infinitum, an income to cover fixed charges, depreciation and operation costs, but is the difference in the fair market value of the entire property immediately before and immediately after diversion. Fair market value is defined as the amount which a willing buyer, not compelled to buy, would pay to a willing seller, not compelled to sell.

The following quotation from the judge's charge to the jury in the Otis case is typical of the charges made in all the cases: ". . . it is not a sum that the petitioner can recover as such, as a separate item, but is evidence that you can take into consideration in determining how much this lost power was reflected in the value of the land after diversion had taken place". This particular quotation applied to water-power damage. The same instructions in all cases were given with reference to testimony relating to pollution damages, to the testimony of real-estate experts and assessors, and to Certificates of Condition filed annually by corporations in Massachusetts, put in evidence. All these were to be given consideration by the jury as elements in arriving at fair market values before and after diversion.

This requirement created some difficulties. Real-estate experts are not water-power experts and water-power experts are not competent to evaluate real estate, and neither are sanitary engineers. The result was that in most cases the jury was not given any direct testimony as to the fair market value of the property concerned after diversion and, in some cases, there was no fair market value pre-diversion testified to, so that in most cases the jury was compelled to consider the capitalized value of the power lost and the capitalized cost of process water and waste treatment, if they considered these claims justified, as the measure of the decrease in fair market value caused by diversion. In other words, these values constituted the damage, which after all is the way in which such damages have been estimated by engineers generally for many years.

In the Boston Duck Co. case, the ninth tried, the Commonwealth put in figures for fair market value both before and after diversion through a real-estate expert, who based his opinions, so far as water-power values were concerned, on testimony of water-power experts. This was a departure from the methods employed in the cases which had been previously tried and gave the jury, for their consideration, definite opinions as to the pre- and post-diversion fair market values of the entire property. The testimony of this real estate expert is given somewhat in detail in the report on that case.

Now, as to the War Department restrictions. Evidence was given in all cases under the assumption that diversions will be made without such restrictions and also, in most cases, under them. In each case until the last (the retrial of the Ludlow Swift case) the judge left it to the jury to decide what consideration they should give to this element. However, the Ludlow Manufacturing Associates Swift diversion case was carried to the Supreme Court and in its opinion that court ruled that compensation should be based on the War Department restrictions.

There are, on the watershed of the Ware River above Coldbrook, a number of ponds, some of which had been used as storage reservoirs for augmenting the low flows of summer. In some of the cases the petitioner brought up an interesting claim with respect to these ponds and their use prior to diversion. The Ware River Act defines the permissible diversion as follows: "meaning thereby that on any day when the natural flow of said river is less than eighty-five million gallons no water shall be diverted". It was claimed that, because of the use of these ponds to store spring flows for subsequent summer use, the flows of the Ware River, which, over the years, had been measured at Coldbrook and Gibbs Crossing, did not represent the "natural" flow and that for the purpose of estimating permissible diversions they should be corrected for the effects of storage. Such a correction would have resulted in raising the estimated permissible diversions and the estimates of power lost because of diversion. However, the judge in each case ruled out such an interpretation of the law and testimony based on it was not permitted. Exceptions were taken, but the cases in which this claim was advanced were settled on the basis of the awards and no ruling was ever made.

With reference to pollution damage claims the Court ruled in the first case tried, the Gilbert case, that each riparian owner was responsible for the condition of the stream as it reached the next riparian owner and that if, because of diversion, he could not discharge into the stream wastes in the amount he had been accustomed to in the past without rendering the stream unfit for use by lower riparian owners, the Commonwealth was responsible for the cost of waste treatment to the extent required to render the stream in as good condition as it was before diversion. Furthermore, quoting from the judge's charge to the jury in the Gilbert case, "it follows therefore that since no riparian owner may unreasonably pollute the stream after diversion any more than he could before, the Commonwealth is not responsible in damages to this petitioner upon the theory that any upper owner may in fact after diversion unreasonably pollute the stream. Owners above the petitioner, like the petitioner itself, must if necessary—whether it is or not is for you to say—conform their use of the stream with respect to casting industrial waste into it to the new conditions so far as there are new conditions created by the right to divert, and if they do not adjust their use of the stream to these conditions, the right of the petitioner is against them for damages and not against the Commonwealth".

The foregoing applies to industrial pollution only. With respect to natural pollution (leaves, surface wash, etc.) the judge goes on to say, "If you find the natural pollution coming into this stream above Gilbertville then, before diversion, was not injurious to the petitioner, but after and in consequence of diversion has been and will be rendered injurious to the petitioner, the petitioner has the right to take such reasonable measures and steps and to adopt such reasonable ways and means as you say are necessary to overcome the effect of such aggravated natural pollution and to ask you to consider that in connection with your determination of fair market value of the property after diversion". In other words, process-water damage claims were ruled out, except as the necessity therefor might arise from an increase in natural pollution. In subsequent cases the same rule was applied.

In reporting the individual cases the writer has given such fundamental data as drainage area, head and capacity of water wheels, and

damage estimates of both water-power and pollution damages, put in evidence by both petitioner and Commonwealth, for what they may be worth, which is probably not much, since there is no way of determining from the lump-sum award how much weight was given to the various claims.

In former years the city of Springfield took the waters of certain tributaries of the Chicopee River for water-supply purposes. The drainage areas thus removed from that of the Chicopee consisted of 11 sq mi on Jabish Brook, a tributary of the Swift River below Winsor Dam, and 8 sq mi on Broad Brook, tributary to the Chicopee between the Palmer Mills plant of the Otis Co. and the Red Bridge hydro-electric station of the Ludlow Manufacturing Associates (now the Ludlow Manufacturing and Sales Corp.). There were several diversion damage settlements made in connection with these takings, which have been reported to this Association by a "Committee Appointed to Collect Data Relating to Awards for Water and Water Power Diversion" and published in Vol. 24 of the JOURNAL (1910). These settlements and others recorded therein are not only given in total, but have been reduced to dollars per foot fall per square mile diverted, for the purpose of comparison. It would be interesting if the same method of comparison could be applied to the amounts paid by the Commonwealth in the settlements reported in this paper, but it is not logical to attempt to make such a comparison where the award covers both water-power and pollution damages. The results would be meaningless.

The Gilbert Case

This case, the first to be tried, was before Superior Court Judge Edward T. Broadhurst and a jury in Northampton, November 20, 1933, to January 4, 1934.

The George H. Gilbert Manufacturing Co. owned three mills on the Ware River, used for the manufacture of woolen and worsted cloth. Two of these mills were located about one-half mile apart in Gilbertville, about 10 miles (by the stream) below the diversion point at Coldbrook, and were operated substantially as one. The third mill was located in Ware, about five miles below Gilbertville.

Each of the mills at Gilbertville had a water power, for which

head, capacity and other data appear in the table on Figure 3. The drainage area is substantially the same at the two plants, 161 sq mi. River water was also used for process work in the finishing departments of both plants—washing and cloth and yarn dyeing—and wastes, including wool-scouring wastes, were discharged into the stream.

The mill at Ware had a low dam diverting water into a canal, which originally led to a water wheel or wheels in the basement of the mill, but the head was not over 6 or 7 ft, and there had been no wheel in operation there for many years. The process water at Ware was piped from the Ware Woolen Co. dam a short distance upstream.

Although the petitioner put on one expert witness to testify as to water-power damage, which was estimated to amount to $54,500, he built his case primarily on pollution damages. It was well planned and executed. An array of lay witnesses, including the superintendent, inspectors and employees in the finishing department, the yard superintendent, a fireman, a pipe fitter, and other employees, the selling agent and a professional cloth examiner, were put on the stand. They testified to dirty, foul-smelling water in the finishing department and boiler house, to difficulties in dyeing, to smelly cloth, to rejected goods and to a foul mill pond, all during the summer of 1931. They further testified that such conditions and difficulties had never occurred before. It was during the spring of 1931 that diversions were first made.

Following these witnesses the petitioner's principal expert witness took the stand. He started in with a long description of the Ware River watershed, comparing the slopes of the tributary streams above Coldbrook with those below Coldbrook, which are steeper than those above. This led up to a dissertation upon the effect of scour in cleansing the stream of organic deposits from both industrial and natural sources and upon the increase in the deposition of such substances, which he claimed would result from diversion. He supported his claims in this respect by the results of a flood test, made by the Commission's engineers in September of 1933, and by an exhibit showing velocities at various sections of the river before and after diversion.

Having set up this picture of increasing deposits of organic mate-

rial, he proceeded to describe the digestion of such material and its effect upon the quality of the water. He supported these claims by a comparison of the analyses of the water of the river in the years prior to diversion with those in the diversion years of 1931 and 1932. It was all very impressive and appeared to explain the bad water conditions previously testified to by the preceding witnesses.

This principal witness' testimony was supported by that of another sanitary engineer.

Two industrial engineers, experienced in the design, operation and evaluation of textile mills, testified to the fair market value of the plants, both pre-diversion and post-diversion, on the assumption that diversion rendered the water unfit for process use. One of these experts placed the fair market of all three plants pre-diversion at $1,207,274 and post-diversion at $324,933, the difference indicating a damage of $882,341. The other valued the Gilbertville mills, exclusive of water power, at $756,486 pre-diversion and claimed that this value would be totally destroyed by diversion, unless water-purification and waste-treatment plants were constructed.

The petitioner claimed that, because of diversion, he would no longer be able to use raw river water for process work, but would be compelled to install and operate a filter plant; that he would no longer be able to discharge his manufacturing wastes into the river without getting into difficulties with lower riparian owners, so that he would be obliged either to curtail manufacturing operations or to install and operate a waste-treatment plant; and that the fair market value of the plants would be reduced to the extent of the cost (including capitalized operation costs) of such plants. The pollution damage claim on this basis amounted to about $800,000 to $1,000,000. The Commonwealth admitted a small water-power damage, denied process-water damage but admitted that wool-scouring wastes at Gilbertville might have to be lagooned and centrifuged.

The Commonwealth's water-power expert placed the water-power damage at $5,620 or, roughly, 10% of the $54,500 testified by the petitioner's expert. The discrepancy in these figures arose from the hours of mill operation assumed, the rates used for the capitalization of annual losses and the fact that the petitioner's expert assumed the installation of additional wheels, which the Commonwealth's expert

testified were not economically justified—that is, the additional power which such wheels would develop could be developed more cheaply by steam.

The Commonwealth produced two eminent sanitary engineers as experts on the pollution-damage aspects of the case. The first of these witnesses testified that "scour has been and will be a minor factor in determining the condition of the river at Gilbertville"; that it is the discharge of manufacturing wastes into the river which has been the controlling factor, and that, if the industrial wastes of the George W. Wheelwright Paper Co. and the Barre Wool Co. (both upstream from Gilbertville) were eliminated, diversion would have no appreciable effect on the water at Gilbertville. These opinions were based on intensive study of the results of scour tests; of water and mud analyses, and a comparison of cross-sections of the Gilbertville pond taken before the September, 1933, flood with cross-sections at the same points taken after that flood. But it was the mistaken strategy of the Commonwealth's counsel to reserve much of this information to be brought out in cross-examination, which, however, did not develop as anticipated, with the result that the jury never did hear the sound basis for the opinions expressed.

The other expert sanitary-engineer witness of the Commonwealth testified that "valley wash"—that is, leaves, silt, manure and trash, washed into the river from the fields, highways and woods—would have no effect on the water at Gilbertville after diversion. He also testified that it is not possible to separate or distinguish between valley wash and industrial wastes in the river. He did state, however, that, because of the loss of diluting water during periods of diversion, there might be necessity for some mild treatment of the wool-scouring wastes at Gilbertville, for which he proposed lagooning before discharge into the river, with centrifuging of the solids settling in the lagoon. The cost of this treatment he placed at $50,000.

The Commonwealth also produced four experts, who testified to a fair market value of the properties ranging from $99,190 to $125,000 pre-diversion, and a number of lay witnesses, mostly former employees of the Gilbert Co., who testified to poor water, troubles with dyeing and rejected goods prior to 1931.

The Charge to the Jury by Judge Broadhurst was thorough and

served as a guide in the trial of subsequent cases. With respect to pollution damage claims, he ruled that the Commonwealth was not responsible for deterioration in water quality caused by industrial wastes, but only for such deterioration as could be traced to "natural" sources, such as leaves and surface wash, and, with respect to waste treatment, that the Commonwealth would be responsible for only such purification of wastes before discharge into the stream as would be required to leave the stream in the same condition as it was pre-diversion, with the same amount of polluting material and no more discharged into it. Of course, the ruling that the Commonwealth would be responsible only for water deterioration caused by natural pollution posed somewhat of a problem to the petitioner's experts in subsequent cases (that of separating quantitatively natural and industrial pollution), but they were never daunted long and, as will be seen, came forward in one of the later cases with what they claimed to be a solution.

The verdict, $305,708.33, which undoubtedly constituted a very considerable victory for the petitioner and was regarded as excessive by those connected with the Commonwealth's side of the case, would seem to indicate that the Commonwealth's case was not very convincing to the jury, but it should be recorded that the new owners had let it be noised about that they proposed to put the mills in operation (they were then idle) with the damage money, as soon as they received it, and there was undoubtedly much local sympathy for the idle operators. Incidentally, it may be remarked that they never did put the mills back in operation.

The Barre Wool Combing Co. Case

This case, the second of those tried, was tried in Superior Court, Worcester, before Judge Lewis Goldberg. The jury was impanelled on June 17, 1935, about a year and a half after the close of the Gilbert case. The verdict was returned July 20, 1935.

The Barre Wool Combing Co. owned and operated a plant, located at South Barre on the Ware River, producing wool tops from raw wool, the processes involved being wool scouring, carding, combing, backwashing and dyeing. In connection with the scouring process the company operated a degreasing plant, in which a considerable

portion of the grease contained in the waste scouring liquor was removed, clarified and sold. The remaining liquor passed through a small lagoon before reaching the river.

The company owned and operated two hydroelectric plants. The upper plant, located about one mile upstream from the mill and about one and one-half miles below the diversion works at Coldbrook, was equipped with a pair of 42-inch wheels, developing 360 hp with 305 cfs of water at 12.5 ft net head. A transmission line carried the power generated to the mill. The drainage area is 100 sq mi and the pond area 23 acres. The lower plant was at the mill in South Barre. It was equipped with 325 hp of wheels, developing that power with 221 cfs of water at 20 ft net head. The pond area was about 23 acres and the drainage area is 103 sq mi.

The petitioner and the Commonwealth each put on one water-power expert. The petitioner's witness testified only to kilowatt-hours lost by diversion, 200,000 per average year, without dividing this into daytime power and nighttime power, and gave the unit costs of purchased power at 12.5 mills per kilowatt-hour between 6 P.M. and 6 A.M. and 16.5 mills per kilowatt-hour for day power, 6 A.M. to 6 P.M., leaving it to counsel to price the 200,000 kwh and capitalize the result in his argument. This counsel did, arriving at an estimated minimum loss of $65,500 and a maximum of $129,000.

The Commonwealth's expert testified to a maximum loss of $39,280.

No claim for process-water damage was made. Obviously, the mill being located only a few miles below the diversion point at Coldbrook with only 4 or 5 sq mi of tributary drainage intervening, the water, post-diversion, would be no worse than pre-diversion and might even be somewhat better, due to the elimination, by the Commonwealth, of former sources of pollution on the watershed above Coldbrook.

The petitioner did claim, however, that the company would be obliged to purify its wastes before discharging them into the stream, in order to insure that the water on reaching the next mill downstream, that of the George W. Wheelwright Paper Co., would be suitable for its reasonable use.

The petitioner put on two sanitary engineering experts, one of whom had served as the star witness for the petitioner in the Gilbert

case. As in that case, this witness described the watershed of the river above and below Coldbrook, and explained scour, deposition, digestion of organic matter, depletion of oxygen and self-purification of a stream. He claimed that because of diversion there would be increased deposits of organic wastes in the bed of the stream and in the Wheelwright pond at the beginning of the summer—the accumulation of materials deposited during the winter months and held there because of lack of scour. To prove this he drew upon the scour test of September, 1933, made by the Commission's engineers, and upon tests which he had made in coöperation with the Commission's engineers of the quality and quantity of wastes discharged into the stream by the Barre Wool Combing Co., giving figures, deduced therefrom, of the tonnage of materials—both total suspended solids and volatile suspended solids—scoured from South Barre to Wheelwright, to Gilbertville and to Ware. He described the scouring action of flood flows as "a sort of housecleaning process".

To prove that pollution at Wheelwright had been increased by diversion he used analyses of the river water at Coldbrook and Wheelwright, made by the Massachusetts Department of Public Health, one in each of the four months July to October, inclusive, during the years 1923-1934, inclusive. He took the sum of the ammonia determinations (nitrates plus nitrites) as his index of intensity of pollution. The intensity of pollution of the wastes from the Barre Wool Combing Co. was expressed by a single factor which he called the "dilution-pollution factor"—the pounds of wool scoured per day divided by the flow of the river at Wheelwright in million gallons per day on the day the sample was collected. The increase of ammonia (at Wheelwright as compared with Coldbrook) in parts per million for each year was plotted against its corresponding dilution-pollution factor. From this plotting he deduced that in 1931, the first year of diversion, the large increase in ammonia in relation to his factor in that year, as compared with pre-diversion years, furnished proof of his claim that pollution at Wheelwright would be increased by diversion.

This witness also deduced from his ammonia studies that, even before diversion, the Barre Wool Combing Co. had been unduly polluting the river at times during hot weather and should have provided

additional treatment by the construction of a larger lagoon, into which the wastes would be pumped at periods of low flow, to be released to the river during high flows.

He then proceeded to describe the waste-treatment plant which, in his opinion, would be required after diversion, to maintain a suitable quality of water in the stream for the use of lower riparian owners.

The testimony of the other expert sanitary-engineer witness of the petitioner, an engineer of national renown, consisted largely of generalizations as to the effects of scour upon the quality of the water in a stream. The effects of diversion he summarized briefly as follows:

(1) An increase in pollution during diversion.
(2) An increased deposition during diversion.
(3) Decreased scour.
(4) A material impairment in the quality of the water at Barre Plains and Wheelwright.

To correct and offset these effects he recommended a waste-disposal system consisting of sedimentation tanks, trickling filters and a final settling tank (humus tank), with removal and disposal of all sludge produced in these processes. The estimated cost of this system, including capitalized (at 4½%) operating costs, was given as $675,100.

The estimated cost, including capitalized operating costs, of the additional treatment by lagooning, testified to by his colleague as necessary pre-diversion, was given as $145,600. This amount deducted from the estimated cost of the post-diversion plant, $675,100, gave a figure of $529,500, which this witness testified to be his opinion of the increased cost of necessary waste treatment brought about by diversion.

For defense against the pollution damage claim the Commonwealth produced two experts—one a national authority on river pollution and self-purification, as well as a teacher and researcher in the fields of sanitary science and bacteriology; the other a well-known sanitary engineer of wide experience.

The river expert testified that any increase in deposited organic matter resulting from diversion would have been completely removed

by digestion by the first of July in any year, so that the condition of the water during the low-flow period of the summer months would be no different from what it would have been had there been no diversion, although the water during May and June would be somewhat impaired by the greater amount of organic matter being digested, but not to the extent that its quality would be as bad as in normal low-flow summer months. He put in evidence data and computations to support this testimony.

The engineer testified that, in his opinion, there would be no material change in the quality of water at Wheelwright due to diversion. This opinion was based upon the relative unimportance of deposition and scour as compared to digestion; upon his study of 16 scour tests which had been made by the Commission's engineers, each covering a definite stretch of river, such as and including that from South Barre to Wheelwright, for the purpose of determining the relationship between rate of stream flow and deposition and scour; and upon the five-day scour test made during the flood of September, 1933 (described on page 199 of this paper), which, according to his computations, showed that of all the organic suspended matter which had entered the Wheelwright pond and the river above up to Coldbrook during the preceding four months of low flow, only 4½% was accounted for at Wheelwright during the flood.

As has been noted, the petitioner's claim amounted to $65,500 (the minimum figure) for water power and $529,500 for pollution damage—a total of $595,000. The Commonwealth admitted $39,800 water-power damage and denied any pollution damage. The award was $189,304.67, which included interest at 4% from March 20, 1931, to July 20, 1934—a total of 17 1/3%—the award as of the date of diversion thus being about $161,300.

The Ware Woolen Company Case

This case, the third coming to trial, was tried before Superior Court Judge George F. Leary and a jury at Northampton, December 2, 1935, to January 30, 1936.

The Ware Woolen Co. owned and operated a plant on the Ware River at Ware, manufacturing woolens. The processes employed included wool scouring, carding, spinning, weaving, fulling and dyeing.

It owned half of a masonry dam and was entitled to one-half of the flow of the stream. The other half of the privilege was owned by the Ware Valley Manufacturing Co., situated on the opposite bank of the stream. Use of the water for developing power had been abandoned by the Ware Woolen Co. in 1929, at which time replacement of the wheels and other repairs would have been necessary. The abandonment of the water power instead of reconstructing was blamed by the petitioner on the knowledge that diversion was only a few years off and no doubt that was a factor in deciding on abandonment.

Water was used for wool scouring, fulling, cloth washing and dyeing. Process wastes were discharged directly into the stream. Claims were made for process-water damage, waste-disposal damage and water-power damage.

The water-power privilege had a net head of 16 ft. The drainage area is 168 sq mi, of which 70 sq mi lie below Coldbrook. As stated above, it was not in use at the time of diversion. Power for operating the mill was being purchased from the Otis Co. at one cent per kilowatt-hour plus a demand charge, under a contract terminable on 60 days' notice. The Ware Woolen Co. had a boiler plant but no steam-driven generating equipment.

The petitioner's hydroelectric expert testified that, under pre-diversion conditions, reconstruction of the water-power plant with 400 hp of wheels and a 270-kw generator at an estimated cost of $43,000 was economically feasible and there was, therefore, a damage due to diversion.

He estimated that 110,000 kwh would be lost to such a plant by diversion. On direct examination he was apparently about to evaluate this at one and one-half cents per kilowatt-hour, to give an annual loss of $1,650 per year to be capitalized [at 5% this would have meant a damage of $33,000; at 8%, $20,600], but counsel for the Commonwealth objected and insisted that he testify, instead, to the cost of replacing the lost power by steam. This he was directed to do after a long discussion among counsel of both sides and the Court. The result was the expert arrived at a damage of $92,500.

The Commonwealth's experts (there were two) both testified that, in their opinion, redevelopment of the water power was not economically practical either before or after diversion but, if redevel-

oped, the capitalized cost of replacing the lost power discounted to 1931 from an assumed date of development, 1941, would be $4,210 as estimated by one expert or $5,000 as estimated by the other.

The petitioner claimed both process-water and waste-disposal damage. A well-known textile chemist testified as to the effects of iron in water used in processing woolen cloth as follows: less than 0.25 ppm, "not extremely serious"; between 0.25 and 0.75 ppm, "increasingly detrimental"; between 0.75 and 1.0 ppm, "decidedly objectionable"; and more than 1.0 ppm, "more or less disastrous".

A sanitary engineer testified that iron in the river would be increased by diversion to more than 1 ppm and hence treatment would be required to render the river water suitable.

All four expert witnesses put on by the petitioner dwelt upon iron and upon the theory that iron is dissolved from the bed of the stream by carbon dioxide released by the decomposition of organic desposits, which it was claimed would result from the loss of scour caused by diversion.

The petitioner endeavored to put in the cost of a water-purification plant—$88,750, including capitalized operating and fixed charges —but it was ruled out by the Court "on the state of the evidence", apparently on the lack of evidence as to the increase in natural pollution caused by diversion and its effect, if any, on the quality of water. There was no evidence in the case as to the quantity or the relative proportion of natural pollution in the stream either before or after diversion.

It was claimed that because of diversion there would be less water available for the dilution of wastes, which, of course, is true during periods of diversion, which, however, cover only about 40% of time. It was pointed out that the average diversion at Ware amounts to 29% of the flow and that, if the flow is reduced that amount, the concentration of a given amount of pollution discharged into the stream is increased 41%. The inference from this presentation of diversion was that 29% of the flow was constantly diverted, when, as a matter of fact, diversion occurs only in periods of relatively high flow, when there is plenty of diluting water at Ware.

The increased deposition of organic matter and increased hangover of same into the summer months was claimed and explained

in much the same manner as had been done by witnesses in previous cases.

The president of the Ware Woolen Co. testified to trouble with processing cloth after diversion in 1931 and 1932, and the superintendent of the George H. Gilbert Manufacturing Co. (who had previously testified in the Gilbert case) told of similar troubles said to have been experienced by that company following diversion.

The Court ruled that the only evidence admissible as to the cost of waste treatment must be for a plant of capacity to handle the wastes of the mill when operating at full capacity and, since the testimony was that operation of the mill at full capacity before diversion would unreasonably pollute the stream, the petitioner must give figures for both a post-diversion plant and a pre-diversion plant. The estimated costs, which include capitalized operation and fixed charges, that went in on these bases were as follows:

Post-diversion plant	$338,920
Pre-diversion plant	154,600
Increased cost of waste treatment necessitated by diversion	$184,320

The Commonwealth in defense of the pollution damage claims put on the same sanitary engineer and the same river-pollution expert as in the Barre Wool Combing Co. case.

The former brought out the actual facts with regard to increased concentration of pollution resulting from diversion, showing that, although the ratio of the quantity of Ware Woolen Co. wastes to the quantity of water flowing in the river is increased by diversion, the actual concentration in parts per million decreases with increase in the magnitude of diversion, due to a corresponding increase in run-off from the 70 sq mi of drainage area tributary to the river between Coldbrook and Ware. He testified, "Whatever standard of process water or waste treatment may be necessary, no additional treatment of the water or of the waste will be made necessary by the authorized diversion beyond that required before diversion under natural low-flow conditions".

The river-pollution expert said that with the existing pollution

load the river below Ware was in unsatisfactory condition; that the critical time for this stretch of river is the low-water, high-temperature period, and that the river would be no worse during that period after diversion than before. Furthermore, he stated that during warm weather 84% of organic matter would be digested in 10 days. This was the theory which he had advanced in the Barre Wool Co. case. His opinions, in general, were based on comprehensive tests of the river made by the Commission's engineers under his direction. His entire direct testimony, given in language which the jury could understand, was clear, complete and impressive.

Both experts stated that the pond sections of the stream are not affected by scour, that the channel sections are sufficiently scoured by flows less than the diversion limit and that there will, therefore, be no increase in objectionable conditions below Ware resulting from diversion.

The petitioner's total claim as stated by counsel in his argument amounted to $230,000. The Commonwealth denied any damage.

The verdict was $88,786.91, which included 19 1/9% interest from the date of diversion. This is equivalent to about $74,540 as of the date of diversion.

The Otis Company Case

The fourth of the cases to be tried was that of the Otis Co. It was tried in Superior Court sitting at Northampton, before Judge George F. Leary and a jury, and covered the period from February 3 to April 17, 1936—more than ten weeks. There were interruptions due to sickness and to the great Connecticut River flood of March, 1936, but the taking of evidence and the view took 37 days.

This case set the high-water mark, so to speak, of the Ware diversion cases, especially with respect to pollution claims, and is unique in that it contained an elaborate attempt to justify a process-water damage claim by divorcing the effects of natural pollution from those of industrial pollution. Because of this fact a rather complete and lengthy review of the testimony is given.

The Otis Co. owned and operated three plants on the rivers affected by the diversions: one on the Ware River at Ware in Hampshire County, known as the Ware Mills; one on the Chicopee River

at Three Rivers in the town of Palmer, Hampden County, known as Palmer Mills; and a third on the Swift River at Bondsville, a village partly in Palmer and partly in Belchertown, Hampshire County, known as the Boston Duck Mills.

The Commission and the Otis Co. had made considerable progress in negotiations for an amicable settlement of all claims pertaining to all of these mills when, after announcement of the verdict in the Gilbert case, further negotiations were called off by the Otis Co.

At the time of the trial, 1936, the Swift diversion had not been made and, although the Commission was empowered by the Swift River Act to negotiate settlements prior to diversion, the parties affected by the Swift diversion could not bring suit in court until actual diversion had occurred. Hence the suit brought by the Otis Co. concerned only the mills affected by the Ware diversion—the Ware Mills and Palmer Mills. Suing for Swift diversion damages to the Boston Duck Mills and to Palmer Mills had to wait. Before the Swift diversion occurred, however, both of these properties were sold and the Swift diversion suits were brought by the purchasers.

The fact that Ware and Palmer are in separate counties necessitated the bringing of a separate petition for each mill and ordinarily two trials, one in each county, would have been required, but by special arrangement both were tried simultaneously in Hampshire County.

The Ware Mills manufactured colored cotton fabrics, principally tickings, denims and awning cloths, starting with raw cotton and ending with the finished product—a complete mill. It had about 43,000 spindles and 957 looms.

The Ware Mills Water Power. The mill had a developed water power of 1,580 hp, divided among 8 units. The total net head is about 45 ft, but only one unit utilized the full head, there being an intermediate canal, dividing the fall, into which certain wheels, taking water from the upper canal, discharged and from which other wheels took water, which was discharged into the river. The head between the upper canal and the intermediate canal was about 27 ft, and that between the intermediate canal and the river about 18 ft. The drainage area at Ware is 168 sq mi.

The petitioner's estimates of the value of the power lost at Ware

by diversion, as presented by its two experts, ran roughly from $40,000 to $80,000. The estimates of the two experts put on by the Commonwealth were $1,500 and $1,870, based on the existing water-power development. Redevelopment to greater capacity was not considered economically feasible by these witnesses. The great discrepancy in the figures of the two sides lay principally in the extent of use of power assumed—that is, in the hours of mill operation—and the rate of capitalization used.

Palmer Mills Water Power. The Palmer Mills water power had an installed capacity of 5,464 hp, requiring 2,127 cfs of water at 27 ft head. The generating equipment consisted of three 1,000-kw units, one 200-kw unit and two exciter units of 75-kw and 35-kw capacity. The net drainage area is 633 sq mi (after deducting 11 sq mi on Jabish Brook, diverted by the city of Springfield). The hydro plant supplied power to the Palmer Mills.

The petitioner's experts' estimates of water-power damage ran from $22,000 to $41,000; those of the Commonwealth's experts, from $13,300 to $18,000. The verdict was $29,698.00. This included interest, amounting to 20.3%, so that the award as of the date of diversion was about $24,700. Since there was no pollution claim in the case of Palmer Mills, this figure may properly be compared with the estimates of experts given above.

Ware Mills Pollution Claims. These claims involved both process water and waste treatment. The petitioner employed, as principal expert witness, the same sanitary engineer who had previously appeared in the Gilbert and Barre Wool Co. cases. The general strategy with respect to the process-water claim seems to have been to have this witness testify to a deterioration in the quality of process water, resulting from an increase in deposits of natural pollutional materials, caused by diversion, and to back this up with testimony of the mill management regarding processing cloth. Of course, the validity of this claim depended on the separation of the effects of natural and industrial pollution—the rock on which process-water claims had been wrecked in previous cases.

The testimony of the sanitary engineer expert with respect to the process-water claim, given on direct examination, was perhaps the most impressive and complete of any testimony presented in any of

the cases tried. It had for its purpose the establishment of the claim that, because of diversion, there would be an increase in both iron and color in the water at Ware, due to natural pollution only.

As in previous cases, this witness started in with a description of the watershed, comparing the slopes of tributary streams above Coldbrook with those below, which he claimed are steeper and carry more suspended matter into the river. He pointed out that this suspended matter brought into the stream by the tributaries was natural pollution, there being no industries on them. He described natural pollution. He described the natural processes which he claimed tend to purify the stream from the effects of natural pollution. These he designated as dilution, digestion and scour.

Diversion, he stated, reduces the amount of water available for dilution of natural pollution, entering the river from the tributaries below Coldbrook.

Digestion of organic matter in the presence of oxygen (aerobic) and in the absence of oxygen (anaerobic) was described in considerable but understandable detail, as were the effects of the digestion of organic deposits in the stream upon the quality of water.

Scour, again described as a house-cleaning process, was given credit, before diversion, with having cleaned out, each spring, the winter's accumulation of deposits in the stream bed, which, because digestion proceeds slowly at low temperatures, were said to have remained practically undigested. The effect of diversion upon scour was illustrated by diagrams, showing the relation between velocity of flow and quantity flowing at various sections of the stream, and velocities before and after diversion were compared. Furthermore, it was claimed that the quantities scoured were dependent not only on velocities but upon the duration of high flows and, to substantiate this claim, the witness presented an estimate of 280 tons scoured between South Barre and Wheelwright during the month of April, 1933—an average of 9 tons per day—which he compared with an estimated 6 tons per day during the 5-day scour test made by the Commission's engineers in September, 1933. The decrease in flow during April, 1933, which would have been caused by diversion, had the diversion privilege been exercised (no diversions were made in 1933), was then pointed out on the flow diagrams in evidence.

At this point in the direct testimony the witness said, "As a result of the increased quantity of organic matter—natural organic matter—accumulating in the bed of the stream due to the loss of scour, there will be an increase in the amount of material undergoing decomposition, an increase in the amount of the products of decomposition, particularly carbon dioxide, an increase in the solution of iron from the river muds from that increased production."

He also testified that a sustained iron of more than 1 ppm would not be satisfactory for process water for the Otis Co.

Then, on the assumption of natural pollution only, "the water would be substantially impaired and rendered unfit for the process purposes of the Otis Co." and "the iron content will be increased, the color will be increased and at times, intermittently, suspended matter will be increased."

The witness then described and presented plans of a water-treatment plant, providing coagulation, sedimentation and filtration, which he would install post-diversion. This plant was estimated to cost $157,400, including capitalized (4½%) annual cost of operation, depreciation and taxes amounting to $97,400. This amount he discounted to 1935 (from 1931, the time of diversion), since, he said, he had computed that the progressive increase of iron from natural pollution would not reach the stage requiring treatment until 1935. The discounted cost of treatment was $132,000.

Before this testimony as to the proposed water-filtration plant was admitted, there was a protracted discussion among counsel and Court, in the presence of the jury, as to its admissibility, the Commonwealth contending that no separation of natural and industrial pollution had been made and that it could not be held liable for industrial pollution. The following portion of this discussion, as it appears in the transcript of the evidence, is interesting and seems worthwhile quoting:

"THE COURT. The presumption is, I suppose, that every owner is using the stream legally.

"MR. NOONAN.* Right. And then the only defect in that water comes about through diversion, and the only thing we seek to remedy is the defect due to diversion. We are not trying to take out any pollution that is illegal, that somebody puts

*John T. Noonan, Esq., appearing for the Otis Co.

in there that is not entitled to put in there. We are trying to restore that water to what it was the day before diversion.

"THE COURT. You have a right to do that.

"MR. NOONAN. That is what we are trying to do.

"THE COURT. But this plan seems to me somewhat indefinite.

"MR. NOONAN. No, it will be perfectly definite, and Mr. ——— has made the studies necessary to restore the water to conditions as before diversion, assuming only natural pollution, or natural plus this little legal industrial pollution that might get in there.

"THE COURT. Can he separate the two?

"MR. NOONAN. I don't see that it is necessary for him to separate the two, if your Honor please, because the sole problem is to restore one type of water to what it was before diversion. We are only dealing with one type of water, the legal type of water we are entitled to get. It is not a question of his taking out illegal industrial pollution in there, because we don't get any illegal industrial pollution.

"THE COURT. You don't get any illegal industrial pollution, but you do get industrial pollution.

"MR. NOONAN. Yes, we may get some, and if that is legal . . . .

"THE COURT. You can't make the Commonwealth pay to eliminate that.

"MR. NOONAN. Wait just a minute, if your Honor please, I think we can. If the upstream owners are sending down to us pollution they are entitled to send down, then the Commonwealth comes along and makes that pollution that is there harmful to us, we have no rights against the upstream owner.

"THE COURT. Oh yes, you have. The upstream owner has got to readapt himself and the Commonwealth has got to pay him for readapting to it, and if he doesn't readapt it the Otis Company can sue him.

"MR. NOONAN. Mr. ———, in his figures, can allow for that readaption. There will still be some industrial pollution after he has readapted it to the lower flow, but adapting it to the lower flow as the upper riparian owners must, then taking that flow at Ware composed of industrial pollution—I mean natural pollution plus the legal industrial pollution—after diversion, I am entitled to ask Mr. ——— what must be done to restore that water to fitness. It contains no bit of illegal industrial pollution.

"THE COURT. The presumption, I suppose, is that with the changed condition of the stream, the upper riparian owner has adapted it.

"MR. NOONAN. He has precisely. He has pulled out his pollution or treated it with something.

"THE COURT. Well, I don't know. I will permit the evidence. I have got to make this clear to the jury when it comes time for the charge, and if the evidence appears to be so indefinite, I may do something then, but I will hear it. I will save your exception."

The Court then addressed the jury as follows: "What I want to

have you keep in mind, gentlemen, is this: the distinction between this pollution that has been termed natural pollution, the valley wash and all that comes into the river, and the kind of pollution that is caused by industry, by mills pouring in their effluent into the stream. The two of them are separate and should be kept distinct so far as you can. Do I make myself clear? All right. I will save your exception. The only thing the Commonwealth can be held for here is the increase of the natural pollution, caused by diversion, whatever effect, if there is any increase in natural pollution, then that is the only type that the Commonwealth can be made to respond for here, provided, of course, that it is shown that increase affects the quality of the water for manufacturing purposes."

The figures or computations, referred to in that portion of the testimony quoted above, by which the witness was said to have separated the effect of natural pollution from that of industrial and to have computed the increase in iron in the stream at Ware, resulting from increased deposits of natural pollution caused by diversion, were not given in direct testimony.

The witness testified that the increase in iron and color, which were said to go together, resulting from increased deposits of natural organic materials brought about by diversion would be progressive; that at the end of the fourth year after diversion the average iron at Ware would be 1.2 ppm and color 117 ppm (he had previously testified that color of 100 ppm, occurring consistently, was the limit for processes of the Otis Co.). He also gave his estimated monthly averages for each of these constituents during the fifth year after diversion, the maximum monthly average for iron being 2.5 ppm and for color 212, both for the month of July. He testified also that the average iron content of the river at Ware before diversion had been about 0.55 ppm and the average color about 58 ppm.

It should be noted here that, although nearly five years had elapsed since diversion, at the time this case was tried, there had been no diversions in either 1933 or 1934, there being no room in Wachusett Reservoir to put the water, if diverted, and Quabbin Reservoir not being completed. Hence, such predictions as were given as to conditions four years after diversion were perfectly safe from being checked against existing conditions. The predictions were based on the diversion of all water permissible.

The expert witness who had testified to these increases in iron and color gave only the results of his computations in direct testimony. The results were so startling, however, the whole testimony was so impressive, and the problem of separating the effects of natural pollution so seemingly impossible of factual and quantitative solution, that it was felt by counsel and experts for the Commonwealth that it was imperative that the method employed by the petitioner's expert and his computations be brought out for analysis and criticism. This was done in cross-examination. The witness' theory or method, which will hereinafter be referred to as the "iron theory", was very ingenious, though considered by the experts of the Commonwealth as far-fetched, of the "strong-arm" variety and, in some respects, erroneous. It is not reported here because of its complexity and length.

In defense of the process-water claim (and of the waste-treatment claim also) the Commonwealth put on two expert witnesses, the same two that were employed in the earlier Barre Wool Combing Co. and Ware Woolen Co. cases—one a sanitary engineer and the other a river-pollution expert, scientist and teacher. Both testified that, in their opinion, diversion would not materially change the quality of river water for process use by the Otis Co.

The sanitary engineer testified:

(1) No diversion may be made when the flow at Ware is less than 145 mgd.

(2) Diversion occurs only 36% of the average year or an average of 4 1/3 months per year.

(3) He demonstrated by chart that 90% of the total amount diverted in an average year is taken during the 10% period of highest flows (his chart showed a flow-duration table, divided into 10 periods of 10% each) and, further, that whereas the concentration of a given amount of pollution was increased by diversion, the concentration diminished with increasing diversion, due to the increasing flow from the 70 sq mi of drainage area between Coldbrook and Ware. This was the same testimony he gave in the Ware Woolen Co. case.

(4) In his opinion, scour is a minor factor in the ultimate disposal of the natural or the industrial pollution. He backed this opinion with sections of the Gilbertville Pond, measured in June, 1933, again in October, 1933, subsequent to the high water of the scour test in

September, and again in the week preceding the testimony after the great flood of March, 1936. The lines of these sections showed no material changes. He said, "It indicates with the largest flood—with a flood four times larger than has ever before been recorded on the Ware River—the mud deposits in the Gilbertville pond have not been seriously or materially changed in surface contour".

(5) Scour occurs in the channel sections of the stream below Ware at flows below the diversion point.

(6) No waste treatment is or will be required by the Otis Co., because:

(a) the stretch of river below Ware will have sufficient velocity to maintain the channel in pre-diversion condition;

(b) scour through Thorndike pond has not been a material factor in determining the condition of the water at Thorndike in the past;

(c) "there is a very marked improvement in the quality of the water between Ware and Thorndike, indicating a capacity of self-purification which, in my judgment, will serve the same purpose and to the same degree after diversion."

(7) It is absolutely not possible to draw quantitative calculations as to monthly scour or deposits from analyses of samples taken a few days in the month and with the flows from the tributaries and at Ware simply proportioned from the recorded flows at Coldbrook. This was a direct and positive refutation of one of the basic assumptions and steps in the "iron theory" of the petitioner's expert.

(8) Natural pollution is "pre-digested" (leaves, grasses, ferns, etc., on the ground) before being washed into the stream. He cited Wachusett and other reservoirs, which collect and hold natural pollution, of which he had made a study, comparing the iron determinations of 29 years of analyses at entrance with those at outlet, with the result of no increase in iron between those points.

(9) In his opinion, iron will not be extracted from the river bed in direct proportion to the organic matter deposited—a basic assumption of the "iron theory" of petitioner's expert.

(10) Analyses do not express the digestive activity of the organic matter deposited, which must be in terms of biochemical oxygen demand to mean anything.

The testimony of the river-pollution expert put on by the Commonwealth began with a dissertation on self-purification of streams, the part played by oxygen, the meaning of biochemical oxygen demand and of oxygen balance, and its use in measuring the condition of a stream. This was given in language readily understood by the jury.

He then described five special 48-hour tests made under his direction—four in July and August, 1934, and one in October, 1935—on the stretch of river from Ware to Thorndike, in which samples were taken hourly at the Otis Co. dam, at the Thorndike dam and at several intermediate points. Flows were measured at Gibbs Crossing (a U.S.G.S. gaging station between Ware and Thorndike) and averaged in each of the successive tests 23, 85, 37, 68 and 26 mgd. Charts were put in evidence, one for each test, showing graphically the progressive changes between sampling points in a downstream direction, in dissolved oxygen, biochemical oxygen demand and oxygen balance. All showed an increasing reduction in the oxygen balance until a critical stretch was reached, beyond which the balance improved.

He summarized his opinion of the condition of the river between Ware and Thorndike under the existing load of pollution as follows: "I see nothing in any of our analyses to indicate that the existing load, both industrial and town sewage, will now or in the near future have an unfavorable effect upon Thorndike pond, which is the next lower industrial water". As to the critical stretch, he said it constituted "a considerable potential nuisance", but that it was uninhabited.

The remainder of the testimony of this witness was largely devoted to breaking down the "iron theory" of the petitioner's expert. The high points of this testimony are as follows:

(1) At temperatures of 45° to 64° F., 84% of the digestible organic matter deposited in the stream would be digested in 10 days.

(2) There is no basis in any reports with which he is familiar that would justify a rate of digestion as low as 12% per month for organic matter in the bed of a stream. The progressive increase in iron, computed under the "iron theory", depended upon the assumed rates of digestion—the lower the rate, the slower the digestion and the greater the hangover of deposits. Twelve per cent per month was the rate assumed by the petitioner's expert for a temperature of 25° C. (77° F.).

(3) His summarization of his investigations and his opinion as to the source of iron in the Ware River is as follows: "I have investigated the various possibilities, first that the iron comes from the river muds as a result of digestion of organic matter. This is not found to be borne out either by making tests of the comparative iron values at Ware as compared with Coldbrook, in view of the increased amount of digestible organic matter added in that stretch. It is not borne out in studies of stream velocity, which presumably affects the deposit of organic matter above Coldbrook, during the fourteen years for which we have iron records. I have also investigated the effect of temperature upon the iron, the annual output of iron through the year by months and find no relation between the temperature and the production of iron in the waters. On the other hand, the study that I have reported of the river muds—the very infinitesimal quantities of iron, when related to the weight of the muds, that can be extracted from these muds by an excessive amount of carbon dioxide (extensive laboratory tests had been made on samples of mud collected from the mill ponds, in which the samples were subjected to treatment by carbon dioxide and the amount of iron recovered determined), which is the product of digestion supposed to be responsible for dissolving the iron—those infinitesimal amounts of iron are entirely insufficient to account for the iron found in the water. On the other hand, I have found a very definite relation, that my studies have disclosed, between the amount of iron carried in the Ware River and the actual amount of water flowing, and that relation, together with my observations on the iron content of dying organic matter, leaves and grass, leads me to a very definite conclusion that the iron in the Ware River occurs naturally as a result of soaking or seeping of vegetation on the hillsides, the dead leaves and grass dissolving out soluble iron. (He had made and reported in his testimony laboratory tests of such materials.) In periods of rainfall and higher run-off we have more of that action going on and consequently more in the stream. At periods of low run-off we are merely drawing upon the storage capacity of the watershed, the ponds and the ground waters to some extent, and those waters all contain their share of iron as they have passed over the vegetation and through the soil, so that the iron seems to be merely a function of the quantity of water. So far as we can show,

The testimony of the river-pollution expert put on by the Commonwealth began with a dissertation on self-purification of streams, the part played by oxygen, the meaning of biochemical oxygen demand and of oxygen balance, and its use in measuring the condition of a stream. This was given in language readily understood by the jury.

He then described five special 48-hour tests made under his direction—four in July and August, 1934, and one in October, 1935—on the stretch of river from Ware to Thorndike, in which samples were taken hourly at the Otis Co. dam, at the Thorndike dam and at several intermediate points. Flows were measured at Gibbs Crossing (a U.S.G.S. gaging station between Ware and Thorndike) and averaged in each of the successive tests 23, 85, 37, 68 and 26 mgd. Charts were put in evidence, one for each test, showing graphically the progressive changes between sampling points in a downstream direction, in dissolved oxygen, biochemical oxygen demand and oxygen balance. All showed an increasing reduction in the oxygen balance until a critical stretch was reached, beyond which the balance improved.

He summarized his opinion of the condition of the river between Ware and Thorndike under the existing load of pollution as follows: "I see nothing in any of our analyses to indicate that the existing load, both industrial and town sewage, will now or in the near future have an unfavorable effect upon Thorndike pond, which is the next lower industrial water". As to the critical stretch, he said it constituted "a considerable potential nuisance", but that it was uninhabited.

The remainder of the testimony of this witness was largely devoted to breaking down the "iron theory" of the petitioner's expert. The high points of this testimony are as follows:

(1) At temperatures of 45° to 64° F., 84% of the digestible organic matter deposited in the stream would be digested in 10 days.

(2) There is no basis in any reports with which he is familiar that would justify a rate of digestion as low as 12% per month for organic matter in the bed of a stream. The progressive increase in iron, computed under the "iron theory", depended upon the assumed rates of digestion—the lower the rate, the slower the digestion and the greater the hangover of deposits. Twelve per cent per month was the rate assumed by the petitioner's expert for a temperature of 25° C. (77° F.).

(3) His summarization of his investigations and his opinion as to the source of iron in the Ware River is as follows: "I have investigated the various possibilities, first that the iron comes from the river muds as a result of digestion of organic matter. This is not found to be borne out either by making tests of the comparative iron values at Ware as compared with Coldbrook, in view of the increased amount of digestible organic matter added in that stretch. It is not borne out in studies of stream velocity, which presumably affects the deposit of organic matter above Coldbrook, during the fourteen years for which we have iron records. I have also investigated the effect of temperature upon the iron, the annual output of iron through the year by months and find no relation between the temperature and the production of iron in the waters. On the other hand, the study that I have reported of the river muds—the very infinitesimal quantities of iron, when related to the weight of the muds, that can be extracted from these muds by an excessive amount of carbon dioxide (extensive laboratory tests had been made on samples of mud collected from the mill ponds, in which the samples were subjected to treatment by carbon dioxide and the amount of iron recovered determined), which is the product of digestion supposed to be responsible for dissolving the iron—those infinitesimal amounts of iron are entirely insufficient to account for the iron found in the water. On the other hand, I have found a very definite relation, that my studies have disclosed, between the amount of iron carried in the Ware River and the actual amount of water flowing, and that relation, together with my observations on the iron content of dying organic matter, leaves and grass, leads me to a very definite conclusion that the iron in the Ware River occurs naturally as a result of soaking or seeping of vegetation on the hillsides, the dead leaves and grass dissolving out soluble iron. (He had made and reported in his testimony laboratory tests of such materials.) In periods of rainfall and higher run-off we have more of that action going on and consequently more in the stream. At periods of low run-off we are merely drawing upon the storage capacity of the watershed, the ponds and the ground waters to some extent, and those waters all contain their share of iron as they have passed over the vegetation and through the soil, so that the iron seems to be merely a function of the quantity of water. So far as we can show,

for every gallon of water there is a certain amount of iron contributed by the watershed. I find no relation whatever—no reason to think that there is any relation—between the digestion of organic matter in the bed of the stream and the iron content of the Ware River."

Waste Treatment. Although the Otis Company's wastes were, except a small amount of relatively harmless liquid, discharged into the sewer system of the town of Ware, which discharged into the river below the village, it was claimed by the petitioner that such a method of disposal might at any time be denied by the town and that the petitioner, therefore, had a just claim for waste treatment.

The petitioner's sanitary engineer expert testified that, in the event that the town did order the company's wastes out of the sewer system, treatment would be required under either pre-diversion or post-diversion conditions; that the pre-diversion plant would cost $21,500; and that the required post-diversion plant would cost $38,000 more, including capitalized operation and fixed charges at $22,800 and $200 for land.

The Commonwealth denied necessity for waste treatment, its experts giving the basis for their opinions that has already been reported herein.

Counsel for the petitioner, in his argument, summed up the claims as follows:

Ware Mills—water-power damage	$ 75,000	
process-water treatment	132,000	
waste treatment	38,000	
Total	$245,000	plus interest
Palmer Mills—water power	$ 33,000	plus interest

The amounts awarded, which included 20.3% interest, were:

Ware Mills	$162,699.97
Palmer Mills	$ 29,698.00

With interest deducted these figures as of March 20, 1931, are about as follows:

Ware Mills	$135,245
Palmer Mills	$ 24,686

The Ware Valley Manufacturing Company Case

This case was tried in Northampton before Superior Court Judge George F. Leary and a jury, May 18 to June 16, 1936. It was the fifth in the series of trials and the last case of a mill situated on the Ware River.

The Ware Valley Manufacturing Co. owned and operated a knit-goods factory on the Ware River at Ware, immediately downstream from the Otis Company's Ware plant, upstream from the Ware plant of the George H. Gilbert Manufacturing Co., and directly across the stream from the plant of the Ware Woolen Co. It owned half of a masonry dam and was entitled to half of the flow of the stream. The other half of the privilege was owned by the Ware Woolen Co. Water was used for developing power and for washing, bleaching and dyeing. Process wastes were discharged directly into the river. The mill had 257 knitting machines.

Claims were made for water-power, process-water and waste-treatment damages. The Commonwealth admitted water-power damage but denied any pollution damage.

The water power had an average head of about 16 ft. The wheels were two in number, mounted on a common shaft, driving a 240-kw generator by a belt. One wheel had a rated capacity at 16 ft head of 203 hp discharging 140 cfs of water; the other, 154 hp and 106 cfs. The mill load was less than the combined capacity of the wheels.

The petitioner and the Commonwealth each put on one expert on water power. The petitioner's expert testified to a damage of $27,600; the Commonwealth's expert to $6,000. Although both experts valued the power lost by diversion at $0.015 per kilowatt-hour, they differed widely in assumptions as to utilization and in rates of capitalization, and the petitioner's expert figured on a redevelopment to greater capacity, which the Commonwealth's expert testified would not, in his opinion, be economically feasible.

The petitioner's expert arrived at his figure by assuming a 108-hour week, with mill load equal to the capacity of the existing water-power plant, obtaining an average annual loss of 82,000 kwh, worth, at $0.015 per kilowatt-hour, $1,230, which he capitalized at 5%, getting a figure of $24,600, to which he added $3,000—his estimate

of the additional loss with a redeveloped plant (15,900 kwh at $0.015, capitalized at 8%)—and arrived at a total of $27,600.

The expert of the Commonwealth put in evidence several estimates, based on different assumptions as to hours of operation and power load, using rates of capitalization varied to suit the degree of speculation involved in each assumption. His figures ran from $900 on the basis of the mill load as it existed in 1931, which was materially less than the capacity of the water-power plant, operating 2,400 hours per year daytime at full load and 3,000 hours per year nighttime at half load, for which case he used a rate of capitalization of 5%, to $7,000 on the basis of a mill load equal to the capacity of the water-power plant, operating 2,400 hours days and 3,000 hours nights at full load, for which he used a capitalization rate of 12%. He gave other estimates, based on other assumptions, which lay between these figures.

In connection with the process-water and waste-disposal damage claims the petitioner employed two expert witnesses—one a textile chemist, the other a sanitary engineer.

The chemist testified to the amount of water required for processing and the permissible amounts of iron therein. The sanitary engineer testified to the average iron before diversion and predicted an increased average iron after diversion, the pre-diversion value being less than the limit set by the chemist and the predicted post-diversion value greater. The necessity for process water having thus been established, the sanitary engineer introduced a plan of a water-filtration plant, which he estimated would cost $10,500 to build and $16,620 to maintain and operate (estimated annual costs capitalized at 5%), or a total of $27,120 process-water damage.

However, cross-examination of the chemist brought out the fact that iron in the past—that is, pre-diversion—during low-water conditions had been consistently in excess of 0.5 ppm (the limit set by the chemist) and, furthermore, witnesses introduced by the Commonwealth showed that the Otis Co. when operating the Ware Valley Manufacturing Co. plant (the petitioner had purchased the knit-goods plant and business from the Otis Co.), had been obliged to filter the river water before use and that the petitioner was purchasing town water for bleaching. These facts seemed to have disposed of the

process-water claim, since the sanitary engineer admitted on cross-examination that it would cost no more to build and operate a filter after diversion than it would before.

But before passing on to consideration of the waste-treatment claim, it should be recorded that the petitioner's expert made no attempt to make a quantitative separation of natural and industrial pollution, proceeding merely on his statement that, in his opinion, substantially all of the iron in the river (average 0.48 ppm before diversion) came from natural sources. In answer to a question, "will you tell us the computation which you did make, if you did make one, to determine the amount of iron that came from natural pollution and that which came from artificial", he replied, "I used the figures of the State Department of Public Health as representing, and it is my opinion that they do represent, the iron from natural sources."

In connection with the waste-disposal claim the sanitary engineer testified that, in his opinion, the post-diversion condition of the river below Ware would be worse than the pre-diversion condition, which he described as being critical at times, and that, inasmuch as the Ware Valley Manufacturing Co. contributed to the pollution causing these conditions, it would be held responsible and that its wastes should be treated because of diversion. He submitted a plan of a waste-treatment plant, which he estimated would cost $10,260. The estimated capitalized cost of maintenance and operation of this plant was $11,060, bringing the waste-disposal damage claim to $21,320.

This testimony was disposed of by showing the actual contribution of pollution from the Ware Valley Manufacturing Co. to be very small—in the neighborhood of 8 lb per day—and bringing out the fact that the sanitary engineer himself had testified in the Ware Woolen Co. case that the river after diversion could satisfactorily dispose of wastes in amounts several hundred times those of the petitioner.

The process-water and waste-disposal claims seemed to have been so completely nullified by the cross-examination of the petitioner's experts that counsel for the Commonwealth decided not to put on any sanitary engineer or other pollution expert, and the low verdict seems to have justified that decision.

The petitioner's claims, as summarized in the argument of counsel, were as follows:

Water-power damage	$27,600
Process water	27,120
Waste treatment	21,320
(as of March 20, 1931)	$76,040
He called it	$76,000
21% interest	15,960
Total claim	$91,960

which was claimed to be the difference in fair market values pre- and post-diversion.

As has been stated, the Commonwealth denied that there was any necessity for either process-water or waste treatment, but admitted water-power damage of $6,000 as of March 20, 1931. The total admission as of the date the case went to the jury was, therefore, $6,000 plus 21% interest, or a total of $7,260.

The verdict was $17,765.22, which was $14,682 as of March 20, 1931, plus 21% interest.

It is, of course, futile to try to determine how a jury arrives at its award, but in this case it seems probable or evident that the pollution claims were discarded and that the award represents some kind of a compromise of the figures of water-power damage testified to by both sides.

Arthur W. Holbrook—Beaver Lake Case

This case was tried in Hampshire County Superior Court, Northampton, June 29 to July 23, 1936, before Judge George F. Leary and a jury. It was the sixth case tried.

Arthur W. Holbrook owned Beaver Lake, an artificial pond on Beaver Brook about 2 miles below Quabbin Dike. He claimed to be developing the pond and its shore properties for recreational use. It was claimed that the construction of the dike, cutting off about 1.6 sq mi of the drainage area of the brook, would result in impairment of the quality of water in the pond—algae, etc.—causing great

damage to his property. The claim was for $63,000. The Commonwealth denied any damage. The award was $9,660.

Ludlow Manufacturing Associates—Ware Diversion Case

This, the seventh case tried, was before Superior Court Judge George F. Leary and a jury, in Springfield, November 16, 1936, to December 22, 1936.

The Ludlow Manufacturing Associates, a voluntary trust, which has since been reorganized as a corporation under the name of Ludlow Manufacturing and Sales Corp., owned and operated a mill situated on the Chicopee River in Ludlow, Mass., manufacturing jute and hemp products, which mill is one of several owned by the company. Its property on the Chicopee River included two hydro-electric plants: one at Ludlow, appurtenant to the mill property; the other at Red Bridge, about 6 miles upstream from Ludlow. The power generated at both plants was used in the mill.

These plants, being located on the Chicopee River, are affected by both the Ware and the Swift diversions, but this case concerned only the Ware diversion. The claim for damage by the Swift diversion was tried later, in 1944, and retried in 1948, both of which trials are recorded hereinafter.

No claim was made for pollution damages. That there was water-power damage was admitted by the Commonwealth.

Pertinent data as of the time of the Ware diversion, March 20, 1931, are as follows:

	Ludlow	*Red Bridge*
Drainage area—sq mi	666	644
Head—ft	41	48
Pondage (3-ft draft)—million cu ft	12	21
Installed generating units:		
Kilowatts (exciters omitted)	2* at 1,600	3 at 1,000
	1 at 350	1 at 1,800
		1 at 200
Total kilowatts	3,550	5,000
Water-wheel capacity (exciters omitted):		
Horsepower	2 at 2,600	3 at 1,650
	1 at 550	1 at 3,000
		1 at 296
Total wheel horsepower	5,750	8,246

*At the Ludlow plant, provision had been made in the original construction (1919) for a third 1,600-kw unit, which had never been installed.

Both hydro plants generated 3-phase 40-cycle current at 11,500 volts, delivering energy to a distributing station at the mill. Power sold or purchased passed through a 40-cycle/60-cycle frequency changer, rated at 1,000 kw. Auxiliary steam station contained one 2,500-kw steam turbine and one 2,000-kw steam turbine.

The combined capacity of the two hydro plants was greater than the mill load, which averaged 3,800 to 4,000 kw and had reached a maximum of 6,800 kw in 1923 (testimony of the superintendent of power and mechanical and engineering departments). A portion of this surplus power during a period of about 11 years had been sold to the Turner's Falls Power and Electric Co. at $0.005 per kilowatt-hour, after conversion from 40 to 60 cycles. This purchase of power had been discontinued by the power company in 1932, because at $0.005 per kilowatt-hour it was no longer profitable (testimony of the general superintendent of the Turner's Falls Power and Electric Co.). In 1936, in order to utilize the surplus hydro power, a 3,000-kw electric boiler was installed and the steam generated by it was used for manufacturing and heating, a saving in coal being thereby effected.

The petitioner put on two hydro-electric experts, who testified to a value of the power lost by diversion of $83,000 and $80,000, respectively. The Commonwealth also put on two hydro experts, who testified to $30,000 and $25,000, respectively. The Commonwealth also put on a steam-engineering expert, who testified to the cost of power generation by steam and to the value of coal savings effected by the use of the electric boiler.

The first expert of the petitioner estimated the value of the power lost by diversion on two bases, namely:

(1) Sale of all power generated at the Ludlow hydro station, with the mill load carried on Red Bridge and surplus power at that plant also sold—estimated capitalized value, $71,370.

(2) Sale of all hydro power generated at both plants to a public utility—estimated value, $94,650.

The expert's estimates on these bases are given in the following tabulations. He testified that, in his opinion, the value of the power diverted was about the mean of these two estimates or $83,000.

Basis 1—Mill load on Red Bridge, with surplus "night" power sold up to capacity of frequency changer; all power generated at Ludlow plant sold. Mill load assumed 5,000 kw 80 hours per week.

	Average kwh diverted yearly	Unit value	Yearly value	Rate of capitalization (%)	Capitalized value
Generating Equipment as of 1931					
Red Bridge—mill use	117,000	$0.0089	$1,042		
Red Bridge—surplus	58,000	0.002	116		
			$1,158	5	$23,160
Ludlow	236,700	0.005	1,183	6.5	18,200
Capitalized value of power diverted, based on equipment in place in 1931					$41,360
Additional Loss if Capacity of Both Red Bridge and Ludlow Plants Increased					
Red Bridge (5,000 to 6,300 kw)	141,800	$0.004	$ 562		
Ludlow (1,760 kw added)	369,300	0.005	1,846		
			$2,408	8	30,010
Total estimated value of power diverted					$71,370

The second hydro-electric expert put on by the petitioner testified that he had based his estimates of power lost by diversion upon plant capacities at both Red Bridge and Ludlow which were economically feasible—that is, upon capacities greater than had been installed but which could be developed without changes in buildings or waterways. On this basis, he estimated that there would be an average annual loss of power caused by the authorized Ware diversion of 777,000 kwh at Red Bridge and 719,000 kwh at Ludlow—a total of 1,496,000 kwh at the two plants. These estimates did not consider the mill load or any other market for the power, but represented the reduction in

Basis 2—All power sold to a public utility—85% utilization factor—conversion 40 to 60 cycles.

	Average kwh diverted yearly	Unit value	Yearly value	Rate of capitalization* (%)	Capitalized value
Generating Equipment as of 1931					
Red Bridge	465,800				
Ludlow	236,700				
	702,500	$0.005	$3,513	6.5	$54,050
Additional Loss if Capacity of Both Plants Increased					
Red Bridge (5,000 to 6,300 kw)	280,900				
Ludlow (1,760 kw added)	369,300				
	650,200	$0.005	$3,251	8	40,600
Total estimated value of power diverted					$94,650

power which could have been developed by the redeveloped plants. This lost power he valued at $0.004 per kilowatt-hour and, capitalizing at 7%, arrived at a figure of $85,480. This was on the basis of purchase of the entire block of power by a public utility. Then "instead of the entire energy loss being sold at 4 mills, that 80 per cent of it, which in my opinion is the proportion which could reasonably be utilized, was sold at 5 mills per kilowatt-hour" and, capitalizing that at 7%, he arrived at the same figure, $85,480. He then said: "Those were simply computations to guide my judgment. . . . There are certain elements involved in the determination of the value of the loss which cannot be taken into account precisely by any system of mathematical computation. Making allowance for those elements, I arrived in my judgment at a figure of $80,000."

The first hydro expert put on by the Commonwealth gave estimates of the value of power lost by diversion on three bases (which he referred to as "schedules") as follows:

Schedule A. Power used for driving the mill, on the assumption of a mill load of 5,000 kw (day load) 2,500 hours per year and 600 kw (night load) 3,750 hours per year, with surplus power sold up to 1,000 kw, the rated capacity of the frequency changer. Generating capacity as existing in 1931.

Under this schedule he found no power lost by diversion.

Schedule B. Power used for driving an enlarged mill, based on a mill use of 9,000 kw (day load) 2,500 hours per year and 1,000 kw (night load) 3,750 hours per year, with surplus power sold up to the capacity of the generating equipment, which was assumed to have been increased over that existing in 1931 by the addition at the Ludlow plant of another 1,600-kw unit, for which provision had been made in the original construction, and at Red Bridge the installation of an 1,800-kw unit in the location of one of three 1,000-kw units in place in 1931 (this change had actually been made in 1934).

Under this schedule he found:

day power diverted—18,000 kwh, which he valued at $0.008 or $144 per year;

surplus power diverted—161,000 kwh, valued at $0.005 or $805 per year.

Thus he found a total yearly loss of $949, which he capitalized at 8%, arriving at a figure of $11,850, which he rounded out to $12,000.

Schedule C. Sale of all power, with continuous operation, 75% utilization factor and redevelopment of generating capacity as in Schedule B.

On this basis he found 1,137,000 kwh diverted, which he valued at 3 1/3 mills ($0.00333) per kilowatt-hour, obtaining an estimated yearly loss of $3,790, which he capitalized at 12%, arriving at a figure of $31,600.

The foregoing estimates were based on diversions occurring the year round. He testified that the figures for diversion only during the eight months permissible under the War Department restriction would be about 20% less.

The other expert hydro witness put on by the Commonwealth testified that, in his opinion, the fair value of the power lost by diversion was $30,000, based on consideration of estimates made by him on five different bases as follows:

Case I.—Hydro plants as in 1931; mill load 5,000 kw days and 1,000 kw nights and week-ends; surplus day power up to 1,000 kw sold.

Under this case he found 2,758 kwh lost to night operation of mill—at $0.01 per kwh = $27.58 per year—capitalized at 5% = $552, capitalized value of power lost.

Case II.—Hydro plants as in 1936 (i.e., after replacement of a 1,000-kw unit at Red Bridge with a modern 1,800-kw unit in 1934); mill load 6,000 kw days and 1,000 kw nights; all surplus power sold.

His estimated loss—capitalized—$35,815.

Case III.—Hydro plants as in Case II; mill load 8,000 kw days and 1,000 kw nights; all surplus power sold.

His estimated loss—capitalized—$35,982.

Case IV.—Hydro plants as in Case II; public-utility use, all power sold.

His estimated loss—capitalized—$31,216.

Case V.—Hydro plants redeveloped to a combined capacity of about 12,645 kw (i.e., same as Case II with the addition of a 1,600-kw unit at Ludlow); public-utility use, all power sold.

His estimated loss—capitalized—$41,570.

In his direct testimony this witness did not, except in Case I, state the values per kilowatt-hour which he used or his rates of capitalization. In cross-examination he said that he had valued power used by the mill—both day power and night power—at $0.01 per kilowatt-hour, surplus day power sold at $0.005 per kilowatt-hour, and surplus night power sold at $0.002 per kilowatt-hour in all cases and, in all cases, had used a capitalization rate of 5% for all mill power and surplus day power sold and 8% for surplus night power sold. Furthermore, his separation of day- and night-power kilowatt-hours was based on the use of pondage to concentrate flows so far as possible into day hours, which he took at 8 1/3 per day—50 hours per week.

The verdict was $52,275, which included 23% interest from March 20, 1931. Thus the award as of the date of diversion was $42,500.

National Scale Corporation Case

This case was tried in Hampden County Superior Court in Springfield before Judge George F. Leary and a jury January 4-15, 1937. It involved the Ware diversion only.

The property involved was located on the north bank of the Chicopee River, below the dam of the Chicopee Manufacturing Corp., and included a dam, canal, water wheel and manufacturing buildings. The only water coming to the petitioner's dam was that which spilled over the Chicopee Manufacturing Corp. dam plus a small amount, estimated at 6 cfs, which the Lamb Knitting Machine Co. was entitled to draw from the Chicopee Manufacturing Corp. canal on the south side of the river, which small draft was discharged into the pond behind the National Scale Corp. dam. The rest of the water diverted into the Chicopee Manufacturing Corp. canal was returned to the river below the National Scale Corp. dam.

Originally a part of the holdings of the Chicopee Manufacturing Corp., the petitioner's property was deeded by the former to one of the latter's predecessors in 1898. This deed and the deeds recording all subsequent changes of ownership specifically excluded any and all riparian rights in the river from the property transferred. Hence, the Commonwealth claimed that the petitioner, possessing no riparian rights, had no claim to diversion damage, unless it could prove prescriptive rights to the water, and the judge so instructed the jury. Material pertinent to the establishment of prescriptive rights was put in evidence and argued.

The jury was out about seven hours and then brought in a verdict for the Commonwealth. The petitioner's expert had testified to an estimated damage of $10,960. It is to be presumed that the jury found no proof of adverse possession, but it may be noted that the evidence as it appears in the transcript seems to be inconclusive as to the existence of any damage, even had there been any prescriptive right acquired. The Commonwealth denied it. No petition was subsequently filed claiming damage due to the Swift diversion.

The Boston Duck Company Case

The trial of this case was before Superior Court Judge William A. Burns and a jury in Springfield, Hampden County, February 12 to April 12, 1940—a period of nearly 9 weeks.

The mill owned and operated by the Boston Duck Co. was located at Bondsville, on the Swift River, about 6 miles downstream from Winsor Dam. It was a cotton-weaving and finishing plant, involving bleaching and dyeing, using river water for processing and the stream for the disposal of wastes—kier liquors, dye-house effluent and domestic sewage.

The damage claims of the Boston Duck Co. covered water power, process water and waste treatment. Water-power damage was admitted by the Commonwealth; necessity for process-water or waste treatment was denied.

Water Power. The water-power development consisted of a masonry dam, about half a mile above the mill, with a canal leading to the mill and to a hydro-electric station, using 546 cfs at 23 ft head and containing three 240-kw vertical units and a small exciter unit; a second dam below the mill, with a canal leading to a hydro-electric plant, equipped with 2 pairs of wheels rated at 302 hp per pair, requiring 167 cfs per pair at 20 ft head, driving a 320-kw generator; and a third station with one 283-hp wheel, driving a 300-kw generator (obviously of much greater capacity than the wheel), and one 52-hp wheel, driving a 30-kw generator, both drawing water from the canal from the upper dam under 20 ft head.

An auxiliary steam plant, which also supplied process steam to the mill, was equipped with a 1,000-kw steam-turbine generator unit and a Corliss compound engine, direct-connected to a 600-kw generator.

The petitioner employed three expert witnesses to testify to the water-power damage. The first of these witnesses testified that the reproduction cost of the existing development was, by his estimate, $606,903, and the depreciated reproduction cost, $354,970; that, in an average year, based on the power requirements of the mill as it was operating during a certain week, the existing hydro developments would deliver 3,650,000 kwh before diversion and 250,000 kwh after diversion; and that the diminution in value of the developed water power was, in his opinion, $535,000, to which he added $8,000 for potential undeveloped capacity destroyed by diversion, his total water-power damage thus being $543,000. The other two hydro-power experts of the petitioner gave figures of $552,200 and $580,000.

The petitioner also put on a steam-power expert, who reported in great detail estimates of the cost of steam for power, processing and heating, before and after diversion, the latter condition involving additions to and remodeling of the existing steam plant. He estimated the additional annual cost of steam brought about by diversion to be about $24,500. This figure was not capitalized.

The Commonwealth put on one hydraulic engineer, who testified to the amount of power which he estimated might have been developed before diversion in an average year on the basis of an 8-hour, 5-day week, 1,876,000 kwh; on a 12-hour, 5-day-week basis, 2,505,360 kwh; and on the basis of a 16-hour, 5-day week, 3,070,080 kwh. He stated that he was not a steam engineer and did not know what it would cost to replace this power by steam.

The Commonwealth also put on a steam engineer, who testified that with certain changes in the steam turbine and the replacement of a pipe to supply steam, extracted from the turbine, for process purposes, which pipe had been demolished in the flood of 1936 and never replaced, it would have been cheaper before diversion to produce all power in the steam plant, and to obtain process and heating steam by extraction from the turbine, than to produce it in the combination of steam and hydro plants and use live steam for processes and heating. In that case the hydro power would, he testified, have been a reserve against breakdown in the steam plant.

To provide a reserve under post-diversion conditions, when the hydro would no longer be in reserve, this witness would install in the existing boiler and turbine house a 750-kw non-condensing turbine at a cost of $48,600, with an estimated annual operating cost (labor, supplies, depreciation, insurance and taxes) of $4,587, which expense, he pointed out, would be more than covered by the elimination of $11,000 in operating costs of the hydro plants testified to by one of the petitioner's witnesses.

The Commonwealth thus put in only this figure of $48,600 for water-power damage. Other hydraulic experts had been employed by the Commonwealth but counsel decided to omit their testimony; to combat the pollution-damage claims with expert testimony denying such damage; and to rely on real-estate experts to testify to fair market values both before and after diversion on the basis of no pollution damage.

Process-Water Damage. This case came to trial early in February, 1940. The actual diversion of the Swift had begun on August 7, 1939, only 7 months earlier. Hence, no reasonable time had elapsed for the determination of the effect of diversion upon the quality of water at Bondsville.

The Agent of the Boston Duck Co., residing in Bondsville and previously superintendent of the bleachery for 7 years, testified that the mill had no trouble with the water before August, 1939; that the water was not as good after diversion; that cloth had been stained after diversion; that these stains could not be removed, although formerly any stains occurring were easily taken out; that black stains were first noticed about August 12 or 14, 1939; and that, because of stains, 30,000 to 50,000 yards had been sold at "off price."

The chief chemist of a large cotton-finishing plant, called by the petitioner, testified that he had analyzed samples of Boston Duck Co. cloth with stains and found iron and manganese in the stains but none in the cloth itself. He explained in detail the process of bleaching cloth and the chemical reactions occurring at various stages of the process which would produce stains, if iron or manganese were present in the water. He placed the safe limit of iron and manganese in the water at 0.5 ppm. He also put in evidence analyses of sand, taken from the filters used by the Boston Duck Co. in its bleachery, which showed both iron and manganese.

A gentleman, who had previously served as resident chemist at Scituate Reservoir of the Providence, R. I., water supply, testified as to analyses for color, iron, manganese, carbon dioxide and various other constituents which he had made of the water of that reservoir, the site of which, like Quabbin Reservoir, had not been stripped of its top soil before filling. These analyses showed bad bottom waters, containing iron and manganese. He compared the soil at Quabbin with that at Scituate, finding them similar, and predicted that the bottom water at Quabbin during the filling period would contain iron in excess of 4 ppm and manganese in excess of 1 ppm and that, for a period of at least 10 years after filling, the iron and manganese would exceed 1 ppm and that this amount would produce stains on cloth in a kier.

His testimony, intended to predict bad water from Quabbin at

Bondsville—water unfit for use in kiers—was considerably damaged by confronting him with the diary of the late Frank E. Winsor, Chief Engineer of the Commission, in which he had recorded that on a certain date he had lunched with the witness, and that the witness had told him that the mills below Scituate Reservoir had never had a complaint and that the water which they received was unquestionably better than before diversion. This the witness admitted.

The star witness on pollution damages put on by the petitioner was the same gentleman who had served so effectively for petitioners in other cases. He described Quabbin Reservoir and the works for releasing water to the Swift River, including a baffle constructed for the purpose of making it impossible to draw bottom water. He explained how, because the reservoir site was not stripped, the bottom water would be devoid of oxygen, and high in color, carbon dioxide and iron and manganese in solution, dissolved from the soil by the carbon dioxide. He described the turnover of spring and fall, when the bottom water rises to the top and becomes diffused throughout the body of the reservoir, and how, when this occurs, the iron and manganese in solution are precipitated by oxygen and sink back to the bottom in insoluble form, to be again dissolved by the carbon dioxide and again lifted by the next turnover. Water drawn to the Swift River, though not drawn from the bottom of the reservoir, would, he claimed, contain iron and manganese during the periods of turnover.

This witness testified that there would be self-purification of the stream between Winsor Dam and Bondsville by reoxygenation and sedimentation, accompanied by a tendency for the iron and manganese in solution to precipitate by oxidation, the manganese requiring more time for this process than iron. He then testified that manganese remaining in solution when it reached Bondsville would be precipitated in the kiers in the bleachery, in the presence of caustic soda used in the boiling process, and that this precipitated manganese would produce stains.

The lack of scour in the Bondsville pond after diversion was pointed out and it was claimed that dissolved-oxygen determinations indicated the formation of carbon dioxide there, which would produce iron and manganese, and he predicted that iron and manganese would

show an increase in the summer to follow. He made this statement: "I would expect an impaired quality of water as regards process purposes at the Boston Duck for the period of years during the filling of the reservoir and for a number of years thereafter".

This witness stated that the existing filters would not remove iron and manganese "to any appreciable extent"; that chemical treatment would be required prior to filtration; and that he would recommend a rapid-sand filtration plant, consisting of aeration, chemical treatment, sedimentation and filtration through sand beds of adequate capacity.

He estimated that such a plant would cost $101,375; that it would be needed for 20 years; and that it would cost $6,760 per year to operate it continuously, or $2,250 per year if operated 4 months per year.

He figured the present worth of 20 years' operating costs at $6,760 per year, capitalized at 5%, to be $84,500. This amount added to the construction cost, gave a total estimated cost of process-water treatment necessitated by diversion of $185,875. This was his maximum figure. He also gave a minimum figure, based on a treatment plant of less capacity, of $103,300.

The Commonwealth was well prepared for the defense against the process-water damage claim and presented a very strong case. Its first expert witness on this phase of the case was a professor in charge of the Department of Chemistry and Dyeing of one of the country's leading textile schools. This witness testified that iron stains are practically always due to rust from contact with iron equipment used in the processes; that the iron in water is usually very small and plays an insignificant part in the staining of textiles; that the percentages of iron and manganese in the materials processed is usually much higher than in the water; and that the same is true of the chemicals and dyes used, in support of which he presented analyses of cloth and of caustic soda.

With reference to the stained cloth put in evidence by the petitioner, this witness stated that he had examined the stains with a microscope and other special instruments, and that they "appeared to be a common, ordinary, dirty kier stain" and were not caused by manganese in the water. He then reported extensive laboratory tests

which he had made in the bleaching and dyeing of various goods, using water with varying percentages of iron and manganese, up to 3.18 ppm of iron and manganese combined. The samples used in these laboratory tests were put in evidence. His evidence concluded with a statement that, in his opinion, water containing up to 3 ppm of iron and manganese would have no effect in bleaching cotton goods and up to 2.12 ppm on the dyeing of pastel shades in wool.

Another expert put on by the Commonwealth was the chief chemist of a large finishing company, who corroborated the testimony of the previous witness in regard to iron in commercial chemicals and dyes, and reported removing a sample stain on Boston Duck Co. cloth by removing the starch by a simple process and washing, concluding "that the spot was some kind of soil, which is simply another word for a dirty spot, acquired by rubbing against something somewhere in the process, that it was there before the goods were starched and should have been removed before they were starched. It was bleached and dyed in and so became imbedded in the fabric".

This witness also reported a full-size commercial test on 10,000 yards of 38-inch cloth, in which the water in the kier boil contained 3.1 ppm of iron and manganese (2.1 ppm iron and 1.0 ppm manganese). He had made this test recently for the express purpose of substantiating his opinion that such a percentage of iron and manganese would be harmless. Large samples of the cloth before being put into the kier, after boiling and washing, and after bleaching were put in evidence. The witness said the finished goods were "commercially perfect."

The Commonwealth also put on another textile chemist, who had formerly been employed by the Otis Co. at Palmer Mills but who, at the time of the trial, was employed by another large cotton mill. This witness testified that in his present employment his company had trouble at times with stains on bleached goods, but always from oil or from contact with dirty surfaces. He did not recall any stains traceable to water. He described and reported the results of four laboratory tests on cotton sheeting, which he had made to test the effect of various percentages of iron and manganese in the water in the kier boil, and further tests to note the effect of iron and manganese on dyeing. The maximum iron and manganese used in the

kier-boil tests was 1.56 ppm and in the dyeing tests, 2.90 ppm. Samples of the cloth used in the tests, taken both before and after treatment, were put in evidence. They showed no detectable defects after treatment.

This witness also stated that in his experience as chemist at Palmer Mills, where the river contains iron in amounts exceeding 2 ppm at times [he referred to 74 analyses in evidence, covering a period of 9 years, in which 29% showed iron in excess of 1 ppm and 16% showed iron over 2 ppm], no trouble had been experienced in dyeing due to iron in the water.

The final witness appearing for the Commonwealth was the scholarly professor who had served in most of the cases previously tried and who has been referred to as the river-pollution expert. His testimony consisted largely of reporting extensive tests, made under his direction, on soil samples from the site of Quabbin Reservoir, with a view to determining the probable extent and rapidity of the solution of iron and manganese during and after the filling of the reservoir; of reporting field tests to determine the rate at which iron and manganese in solution will precipitate out in a stream; and of discussing an extensive series of analyses of samples of Swift River water, collected daily at Winsor Dam, at Bondsville and at two intermediate points over a period of about 6 months, immediately preceding the trial.

His conclusions may be summed up as follows: he predicted that during the fall of 1940 (the case was being tried in the spring of 1940, following commencement of diversion in the previous August) the iron and manganese in the water released at Winsor Dam would not exceed 2 ppm; the water at Bondsville in 1940 would not contain over 1 ppm of these elements; the color in 1940 would not exceed that of the past; the water released in the fall of 1941 would not contain iron and manganese in excess of 1 ppm, which would be reduced to not over 0.5 ppm at Bondsville, and the water at Bondsville in future years would be better than in the past.

Waste Disposal. The sanitary engineer testifying for the petitioner pointed out that 90% of the water in the Swift River would be diverted, which, he said, would mean that, on the average, there would be only 10% of the water available for dilution of wastes. This,

while literally true, presented a distorted picture, since the low-water flows, which determine the necessity for waste treatment, before diversion were often not greatly in excess of 20 mgd at Bondsville and on a few days had been less. However, he testified that, although on the basis of 90% loss of diluting water a removal of 90% of the impurities is called for, which would involve equalization of wastes, treatment with chemicals, filtration through sand and disposal of sludge, he thought as a practical matter of control of stream pollution that sand filtration could be omitted and that treatment consisting of equalization, chemical treatment, sedimentation and the disposal of sludge in lagoons would be sufficient. He estimated the construction cost of such a plant for treating the wastes of the Boston Duck Co. at $105,790. Adding to this capitalized depreciation and operating costs, he arrived at a total estimated cost of waste treatment amounting to $358,030.

For the Commonwealth the river-pollution expert testified, "Even assuming a restriction of the stream flow to exactly 20 mgd . . . the stream at N-3 (a sampling station about 2.5 miles below Bondsville) and at points below will never, under loads as they existed this summer, even approach a condition of unbalance (referring to oxygen balance) or breaking-down of this stream". This conclusion was based on a study of the stream below Bondsville, in which samples had been taken at stations immediately above and below Bondsville and at station N-3, 2.5 miles below Bondsville, at hourly intervals, 24 hours per day during the 5 days per week when the mill was running, over a period of 13 weeks. The analyses of these samples were put in evidence.

Estimates of Fair Market Value. The Commonwealth produced a real-estate expert, who placed the fair market value of the property before diversion at $461,887 and after diversion at $401,841—a decrease in fair market value due to diversion of $60,046. His method of arriving at these figures was based on rental of the property—a method unique in these cases but used by him in two subsequent cases. It gave the jury something to hang their hats on, inasmuch as it gave them an expert's figures for fair market value both before and after diversion, and from the amount of the verdict, $62,267.43, it looks as though they did just that.

Since the jury seems to have accepted the testimony of this expert at face value (of course there is no way of knowing that this was actually so), it will be outlined here. The figures given below are those applying to pre-diversion conditions.

Gross income was figured as follows:

Space rental—762,753 sq ft	$86,400.00
Sale of power to tenants—	
2,500,000 kwh at $0.0125	31,250.00
Sale of steam for process work—	
68,500,000 lb at $1.00 per thousand	68,500.00
Gross income	$186,150.00

From this gross income 15% was deducted, to allow for vacancies, uncollectible rents, etc., and there remained what the witness called a "stabilized income" of $158,227.50.

From this was deducted estimated annual expenses (supplies, labor, repairs, fuel and insurance) of hydro-electric plant, steam plant and buildings, totaling $79,344. The witness gave the figures for those items in detail, using, in part, hydro-plant costs previously testified to by the petitioner's expert and steam-plant figures which he said had been furnished by one of the Commonwealth's experts, who, at the time this testimony was given, had not yet testified.

After deducting these expenses from the estimated "stabilized income", there was left $78,883.50, which he said was the "amount that the land and the buildings and the improvements are earning, and this is the amount that in my opinion determines their worth."

From this amount he deducted estimated taxes on the buildings, $15,746, depreciation of $16,270.80, and expense chargeable to land investment (taxes and 10% return) amounting to $3,128, leaving $43,738.70. The depreciation given was based on amortizing the investment in buildings in 20 years, the sum of $16,270.80 being the amount which it would be necessary "to set aside" each year, "to recoup the money that you invest in the buildings and improvements at the end of their useful life—at the end of the time in which you don't think they will continue to earn this sum of money."

The residual annual income thus estimated, $43,738.70, was then

capitalized at 10% and this computation resulted in a figure of $437,387 for the amount which a purchaser or investor would be willing to pay for the buildings and improvements—that is, the property exclusive of land. To this was added the estimated value of the land, $24,500, the result being a figure of $461,887 which the witness said, in his opinion, represented the fair market value of the property before diversion.

In estimating the fair market value after diversion, it was assumed that diversion had no effect on the quality of water in the river or upon the ability of the stream to take care of wastes in the amounts and of the quality discharged by the Boston Duck Co. [the Commonwealth denied any necessity for either process-water or waste treatment after diversion].

The witness carried the post-diversion figures through in the same way he had estimated the pre-diversion fair market value. The only differences in these post-diversion figures were the omission of hydro-plant expenses, an increase in steam-plant expenses (since, with the elimination of hydro power, the 2,500,000 kwh assumed to be sold to the tenants would have to be developed in the steam plant), and a reduction in the taxes and depreciation on buildings, resulting from the abandonment of hydro power.

The final figure of fair market value after diversion, arrived at in this way, was $401,841.

The Commonwealth also put on a second real-estate expert, who testified to a pre-diversion fair market value of the property of $375,000 and a post-diversion fair market value of $325,000, giving an estimated diminution in fair market value, caused by diversion, of $50,000.

The jury thus had for consideration the damage claims of the petitioner as follows:

Water power	$543,000	to	$580,000
Process water	103,300	to	185,875
Waste treatment	358,030		358,030
Total	$1,004,330	to	$1,123,905

and the testimony of the Commonwealth's two real-estate experts that they estimated the damage at $60,046 and $50,000, respectively.

The verdict was $62,267; the final settlement by agreement, $88,423.

Palmer Mills Swift Diversion Case

This case was tried before Superior Court Judge Edward T. Broadhurst and a jury in Springfield, October 6-17, 1941. It was the tenth case coming to trial.

The property involved is located on the Chicopee River and was therefore affected by both the Ware and Swift diversions. It was originally developed, owned and operated as a cotton mill by the Otis Co. and the Ware diversion damage was included in the trial of the Otis case, which has been reported herein.

The case under discussion covered the Swift diversion damage. The petitioner was Palmer Mills, Inc., a corporation the stock of which was owned indirectly by the same parties which had come into possession of the Boston Duck Co.

The Palmer Mills property consisted of a group of mill buildings and a hydro-electric plant, located about half a mile downstream from the mill, with an electric transmission line connecting the two. The mill buildings were unoccupied at the time of diversion and at the time of the trial, and had been allowed to deteriorate. The hydro plant was operated by Palmer Mills, Inc., and the power generated was sold to the New England Power Co. under a contract which provided a payment of not less than $1,000 per month and $0.002 per kilowatt-hour for all power in excess of 250,000 kwh delivered in any month.

Data regarding the hydro plant will be found under the report on the Otis case. There had been no change in generating equipment between the time of the Ware diversion and that of the Swift diversion.

As compared with most other cases this case was brief, lasting less than two weeks. The petitioner put on only four witnesses—two lay witnesses, to put in basic data, and two water-power experts. The Commonwealth put on two real-estate experts and no other witnesses. The petitioner tried its case on the basis of divorcement of the hydro plant from the mill property, putting in figures of fair market values,

pre- and post-diversion, of the hydro plant alone, leaving the mill out of the picture entirely. The Commonwealth, on the other hand, gave figures covering the entire property.

One of the petitioner's experts placed the fair market values of the hydro plant as pre-diversion, $373,000, and post-diversion, $150,000—a damage of $223,000. The other expert gave his opinion of fair market values as pre-diversion, $273,000, and post-diversion, $88,000—a damage of $185,000. Both figured the amount of available power lost by diversion on the basis of 85% utilization. One valued all available power at $0.004 per kilowatt-hour, on the assumption of sale to a public utility; the other at $0.007 per kilowatt-hour for the first 2,000,000 kwh, on the basis of use of that amount by the mill, and $0.002 per kilowatt-hour for the remainder, presumably to be sold. Both experts used a capitalization rate of 6%. Each estimated the pre-diversion fair market value and obtained his post-diversion fair market value by deducting therefrom his capitalized value of the estimated loss of income plus, in the case of one witness, other alleged losses as noted in the following paragraph.

This witness found a loss of prime power which, valued at $15 per kilowatt per year, he added to the estimated value of his kilowatt-hour loss. He also made the claim that, because of diversion, the station would be overdeveloped for the available stream flow, so that one unit would be abandoned, when the time came for replacement, and its production would thus be lost from that time on—production, not as it existed, but at the higher efficiency of a modern unit. This future power loss he estimated to be 583,000 kwh per year, valued at $0.004 per kilowatt-hour, worth $2,332. This he capitalized at 8%, obtaining a future loss of $29,150. But this he claimed was not the total future loss. He made the additional claim that, because of the future elimination of one of the large generating units, the power-plant building would be "larger than warranted by the river" and "that extra investment, now (i.e., in the future) rendered useless by diversion, is an element in reduction in value". The reduction in value on this score he placed at $17,000. How he arrived at this figure was not brought out either in direct testimony or cross-examination. This amount brought his estimated future loss to $46,150, which he assumed would occur 15 years after the date of diversion. Discounting at 6% he obtained a present (1939) value of future loss of $18,000.

The real-estate experts put on by the Commonwealth both estimated the fair market value of the entire property pre-diversion and post-diversion, both following substantially the same method of estimation as used by them in the Boston Duck Co. case. This method, which might be called the realtor's method of appraisal of real estate, consisted of estimating a net annual income from the property, from rental of floor space and sale of power, and capitalizing that at a rate to cover return on investment, taxes and depreciation. One witness took the investment return rate at 10%, taxes at 4% and depreciation (based on return of original investment in 20 years) at 3.72% —a total of 17.72%. The other witness took the investment return at 8%, taxes at 4.16% and depreciation at 4%—a total of 16.16%. The value of the land was added to the amount determined by this capitalization and the estimated cost of repairs necessary to make the buildings rentable was deducted.

A further word regarding the Commonwealth's case may be in order. The real-estate witnesses were permitted to testify as to income from the water power, because they based their figures upon testimony put in by the petitioner's experts and data in evidence. The petitioner's experts had testified to the available power at 100% utilization, both pre- and post-diversion. The real-estate experts took these figures and applied to them a utilization factor of 60%, which, from study of power-production records and other data in the case, they determined to have been the average use of available power over a period of years. They then evaluated this power on the basis of the existing contract for the sale of power to the New England Power Co.

The War Department restrictions were not mentioned in this case.

The damage, as of the date of diversion, testified by the petitioner's experts, as noted above, amounted to $223,000 and $185,000, respectively. As testified by the Commonwealth's experts, it amounted to $21,246 and $24,000, respectively. The jury award was $84,747, which included 9% interest, the award as of the date of diversion thus being $77,750.

Ludlow Manufacturing Associates—Swift Diversion Case

This case was tried in Springfield before Superior Court Judge Edward T. Broadhurst and a jury, November 14 to December 14, 1944, and covered the claims of the petitioner to damages resulting from the Swift diversion. The Ware diversion damage had been tried and settled in 1936, which case has been reported hereinbefore. No claim for pollution damages was made in either case. The Commonwealth admitted water-power damage.

The report on the Ware diversion case contains a tabulation of data pertinent to the water-power damage claim, including a listing of the power-generating equipment, as of March 20, 1931, the date of the Ware diversion. This tabulation holds good for the date of the Swift diversion, August 7, 1939, with this exception: of the three 1,000-kw units at Red Bridge in 1931, two had been rendered inoperable by the removal of the wheels and the third had been replaced by a modern 1,800-kw unit—the net result being a reduction of the rated generating capacity in place at Red Bridge from 5,000 to 3,800 kw. There had also beeen installed in 1936 an electric boiler, rated at 3,000 kw.

The situation in this case was unusual in several respects. The company had two hydro plants, constructed for the purpose of supplying power to the mill, the combined capacity of which was greatly in excess of the mill load and, except during periods of low water, a large amount of surplus power was available. A portion of this surplus power had been sold during a period of 11 years (1921-1931) to the Turner's Falls Power & Electric Co. at $0.005 per kilowatt-hour, measured on the delivery side of a frequency changer, the delivery capacity of which was about 1,000 kw. Power sold during this period averaged a little over 2,000,000 kwh per year. This outlet for disposal of surplus power had been closed early in 1932 by cancellation by the power company, because it no longer found the purchase profitable. In 1936 the company had installed a 3,000-kw electric boiler, to utilize surplus power up to its capacity for the generation of steam for process use and heating. Surplus power so used was testified to be worth about $0.0013 per kilowatt-hour, that representing the saving in coal effected. During the 25 years, 1915-1939, no other use had been made of available surplus power than that noted above.

An additional 1,600-kw unit, for which provision had been made in the original construction, could be installed in the Ludlow plant at a reasonable cost and the two 1,000-kw units at the Red Bridge plant, which had been partially dismantled by removing the wheels in 1938, could be replaced with new units and put in service without great expense.

There was, therefore, a large amount of surplus and potential power to be considered in evaluating the effect of diversion and here the realms of speculation entered.

The petitioner's experts took these potentialities into account, but the Commonwealth's experts limited their figures to the existing plant equipment, claiming that, because there was no external market for surplus power, development of the potential power was not justified.

The petitioner put on two witnesses who placed in evidence basic data regarding stream flow, diversions and the mill property, including the power plants and daily log sheets of same, and they were followed by an experienced building contractor, who testified to the reproduction cost of the buildings, exclusive of the hydro plants. His figure was $5,139,611. He did not depreciate it.

These witnesses were followed by two water-power experts, the first of whom testified to the fair market value of the hydro plants before and after diversion, as estimated by him on two different sets of assumptions, which were referred to as Case I and Case II.

In Case I it was assumed:

(a) that both hydro plants were fully developed by the replacement of two inoperative units at Red Bridge and the addition of a third unit at Ludlow—giving a combined generating capacity of 11,430 kw;

(b) that all power generated would be used to supply a mill or mills, assumed to be constructed on company-owned land, requiring 11,430 kw 80 hours per week (the average 80-hour mill load during the years 1932 to 1943, inclusive, was 3,458 kw);

(c) that deficiency in water power would be made up by purchase from a public utility.

The witness' direct testimony on his Case I was brief and con-

sisted of his figures of fair market value of the two hydro plants as follows:

Pre-diversion	$2,150,000
Post-diversion	1,328,000
Diminution in value, or damage (Case I)	$ 822,000

Practically no further information was given by this water-power expert in direct testimony. He did not testify to kilowatt-hours generated and purchased, cost of purchased power, rates of capitalization used and other pertinent data. Cross-examination brought out that about 24,000,000 kwh would be furnished by hydro and about 22,000,000 would have to be purchased, under the assumptions of this Case I.

The following question and answer from the cross-examination sums up Case I, as viewed by counsel for the Commonwealth:

Q. It comes to this, doesn't it, Mr. Witness, that in your Case No. I, in order to avail himself of your assumption, you are going to require a willing buyer, in August of 1939, to pay the sum of $2,150,000 for two certain hydro-electric plants, based on the further assumption that he is to provide, or will secure, or will find, somewhere, a mill capable of using more than three times the present mill load of the Ludlow plant, and for that purpose additional buildings, additional machinery, additional employees, in such ratio as may be reasonable under such circumstances, would be required, relying upon a production of 24,000,000 kwh of electricity and requiring the purchase of 22,000,000 kwh of electricity per annum; is that a fair statement?

A. Yes, sir.

In Case II it was assumed:

(a) that the Red Bridge plant was sold or leased for public-utility use;

(b) that the Ludlow plant would be used to drive the mill as it existed in 1939;

(c) that surplus hydro power from the Ludlow plant would be sold through the existing frequency changer;

(d) that the remaining surplus power would be applied to the electric boiler;

(e) that the Red Bridge plant was converted from 40 to 60 cycles and that the inoperative units were replaced by new units;

(f) that the Ludlow plant remained at existing capacity and at 40 cycles.

The witness described his method of estimating the fair market value of the hydro plants, pre-diversion, and gave his computations in detail. His fair market value, post-diversion, was obtained by subtracting his estimate of the value of the power lost by diversion from the fair market value, pre-diversion.

In estimating the pre-diversion fair market value of the Red Bridge plant, the witness first figured gross annual income or value by placing a value of $0.004 per kilowatt-hour on the number of kilowatt hours which he estimated could be developed by the enlarged plant, assuming a utilization factor of 85%, and adding thereto his estimate of capacity or prime power, valued at $15 per kilowatt per year. From this estimated gross annual value he deducted estimated annual operation and maintenance costs, taxes, insurance and depreciation. He then capitalized the remainder at 6% and deducted therefrom the cost of adding new units in place of the two units from which the wheels had been removed, the cost of changing the existing units from 40 cycles to 60 cycles, and depreciation. The resulting figure, $902,814, was his estimated fair market value. Actually his testimony was not quite so simple, since he made separate sets of figures for the existing units and for the new units but, in effect, his method was as described.

To estimate the pre-diversion fair market value of the Ludlow plant, the witness first divided the power which could be developed into four classes: (1) that which could be used by the mill, on which he placed a value of $0.0087 per kilowatt-hour; (2) surplus day power, sold through the frequency changer, valued at $0.005 per kilowatt-hour; (3) surplus night power, sold at $0.003 per kilowatt-hour; and (4) additional surplus power supplied to the electric boiler, worth $0.00135 per kilowatt-hour. From the gross annual value of the pre-diversion power thus obtained he deducted estimated annual operation and maintenance, taxes, insurance and depreciation charges, obtaining an estimated net annual value of $61,109, which he capitalized at 6%, arriving at a figure of $1,018,483, to which he added $52,500 for present (1939) worth of 700 kw of prime power. From

this sum, $1,070,983, he deducted depreciation to 1939, amounting to $225,516, and obtained his pre-diversion fair market value of the Ludlow hydro plant—$845,467.

The value of the power lost by diversion was estimated as follows:

At Red Bridge the kilowatt-hours lost by the existing units were estimated and valued at $0.004 per kilowatt-hour, and the prime capacity value was assumed reduced by 10%. This resulted in an annual loss for the existing units, which, capitalized at 6%, gave a figure of $248,750. But the witness said that diversion made re-installation of the abandoned units uneconomical, so that the value of those abandoned units, which he had estimated to be $134,300, was destroyed by diversion and the total lost value at Red Bridge was $248,750 plus $134,300, or $383,050.

At Ludlow he figured the value of the power diverted from each of the four classes of power which he had considered in estimating pre-diversion value and capitalized the total at 6%. To this he added 10% of the value of pre-diversion prime power. The result was $297,883.

His final figure for the value of the power lost by diversion in his Case II was, therefore:

Red Bridge	$383,050
Ludlow	297,883
Total	$680,933

The second water-power expert put on by the petitioner treated the determination of the value of the power lost by diversion in a broader manner. He figured on three bases.

Basis 1—"unit-price basis":	
Available power—both plants	
Pre-diversion, 7,310 hp at $300	$2,193,000
Post-diversion, 5,890 hp at $250	1,472,000
Diminution in value	$ 721,000
Basis 2—per-square-mile-per-foot-fall basis:	
Square miles drainage area diverted—186	
Fall—both plants—89 ft	
Diminution in value, $40 \times 186 \times 89 =$	$662,160

Basis 3—replacement basis:	
Power lost at 85% utilization factor, 7,862,500 kwh	
Cost of replacing this lost power at $0.0055 =	$43,244
Diminution in value (capitalized at 6%)	$720,700

This witness testified in conclusion, "I feel that the diminution in fair market value was not less than $600,000".

Up to this point the petitioner had put in evidence the reproduction cost of the company's plant, exclusive of the water-power plant; the fair market value of the water-power plants before and after diversion; and the value of the power diverted, estimated on several different bases or sets of assumptions. A real-estate expert was then put on, who testified to a fair market value of the entire property, including the water-power plants, as

Pre-diversion—not less than	$4,100,000
Post-diversion—not less than	3,375,000
Difference or damage	$ 725,000

The pre-diversion fair market value, as testified by this witness, was composed of the following:

Buildings	$2,113,950	(the reproduction cost previously testified to, depreciated by this witness)
Water-power plants	1,900,000	(based on testimony of one of the water-power experts)
Land	103,125	
Total	$4,117,075	

which was rounded out as "not less than $4,100,000".

The testimony of this witness as to how he arrived at his post-diversion fair market value is not all clear, but it is probable, and seems evident, that he actually assumed that the value of the lost power represented the diminution in fair market value of the petitioner's property, and that he picked a value between the figures of $822,000 and $680,000, which had been testified to by the first hydro expert, adding about 30% of the difference between these figures to the lesser. This value was $725,000 and the post-diversion fair mar-

ket value was probably obtained by subtracting that amount from the pre-diversion fair market value.

The Commonwealth's case was brief. Two water-power experts testified to the average annual value of power lost by diversion, each basing his estimate on the generating equipment as in place in 1939 and upon the average annual mill use of power over 29-year and 25-year periods—about 11,700,000 kwh per year—with sale of surplus power through the existing frequency changer, within its capacity, and remaining surplus supplied to the electric boiler. One of those witnesses estimated the average annual value of the lost power at $11,460; the other at $10,723. Neither witness capitalized his value. No estimates were given based on any other set of assumptions.

Two real-estate experts were called by the Commonwealth, both of whom testified to pre-diversion and post-diversion fair market values, basing their figures, so far as the water powers were concerned, upon the testimony of the hydro experts. One real-estate expert placed the damage at $118,000; the other at $95,000. The fair market values, as testified by one of these witnesses, were pre-diversion $1,828,000 and post-diversion $1,710,000. The corresponding figures of the other witness are not available (the transcript is missing). The witness whose figures are given appeared for the Commonwealth in the Boston Duck Co. case and his method was substantially the same as employed by him in that case, in the report of which it is described in some detail. He figured a gross annual rental of the buildings (on a price-per-square-foot basis) and the mill yard and an annual value of the hydro power, based on existing generating equipment and a mill use of 12,000,000 kwh per year (about the 29-year average) and upon figures of power available, put in evidence by the Commonwealth's hydro experts. These two estimates gave an estimated gross annual income, from which deductions were made for vacancies and contingencies, care and management, repairs and maintenance, taxes, depreciation (assuming amortization of the purchaser's investment in 25 years), insurance, and land charges (taxes and interest on investment in land), leaving a sum, $126,238, representing net annual income, which he capitalized at 8%, obtaining a value of the property, exclusive of land, of $1,577,979. Adding to this his estimate of the value of the land, $250,000, gave

what he considered to be pre-diversion fair market value—$1,828,000.

His post-diversion fair market value, as has been stated, was $1,710,000. This represented an annual net income of $116,800, capitalized at 8% ($1,460,000), plus land value of $250,000. He did not give his post-diversion figures in detail, except for the estimated annual gross income from hydro power, which was $170,500. This was $22,250 less than the corresponding pre-diversion figure, which was $192,750. Although the only difference between his pre- and post-diversion figures for gross income was that arising from the loss of hydro-power income, $22,250, his estimated loss in net income was only $9,438. This discrepancy arose from his method of figuring deductions from gross.

Before closing the report on this case, it seems worth while to mention briefly some evidence which, while having no direct quantitative bearing, was interesting and may have carried some weight with the jury.

The company in 1935 had brought before the Board of Tax Appeals a plea for a reduction in the assessment of taxes, imposed upon it by the town of Ludlow. The president of the Ludlow company was called to the stand by the Commonwealth and confronted with statements which he had made at the hearing before the Board, which statements were widely at variance with many made by the petitioner's witnesses.

The Commonwealth introduced evidence to show the effect of storage in Quabbin Reservoir in reducing future floods in the Chicopee River. The company had suffered damage in the hurricane flood of 1938 and the extent to which that flood would have been held back, if Quabbin Reservoir had been in operation, was stated. The judge, in his charge, told the jury that they might take such testimony into consideration and that if they found that the construction of Quabbin Reservoir had benefited the petitioner they should deduct such value as they might assign to such benefit from the difference between the post- and pre-diversion fair market values, as determined by them. Exceptions taken to the admission of the flood testimony were sustained by the Supreme Court.

One exhibit in the case deserves recording here, since the Commonwealth built its case to a considerable extent upon what it reveals

as to the actual use made of the hydro power over a period of 29 years. This exhibit, which appears as Table 3, was compiled from records of the company and admitted by the petitioner to be correct.

The verdict brought in by the jury was $239,582.90, which included 21.4% interest from August 7, 1939. The award as of the date of diversion was, therefore, $197,350.00.

Ludlow Swift Diversion Case—Opinion of Supreme Court

Being dissatisfied with the amount of the verdict, the petitioner carried the case to the Supreme Court on certain exceptions to rulings on evidence. The opinion handed down, 321 Mass. 240, may be briefed as follows:

(1) "It was error to admit evidence of damage caused to the property by the extraordinary floods, unlikely to occur again, accompanying the hurricane of 1938, upon the theory that the construction and operation of the reservoir would either reduce or eliminate any future damage to the property". (Quoted from court reporter's summary of the opinion.)

(2) Evidence of the nature and effect of the War Department restrictions on the flow of the Chicopee River was properly admitted. It was immaterial that the restrictions had not been enforced; non-enforcement would not destroy their validity. The restrictions were incorporated in the order of taking and compensation should be assessed on the basis of diversion to the full extent permitted by the order as of its date. If the restrictions were subsequently made more onerous, thus benefiting the petitioner, his compensation would not be diminished thereby, and if the restrictions were subsequently made less onerous, a greater amount of water could not be withdrawn without a new taking and a new assessment of damage therefor.

(3) Evidence of the possible effect of the installation of a hydro-electric unit at Winsor Dam was inadmissible.

(4) Exclusion of the report of the Metropolitan District Water Supply Commission for the year ending November 30, 1937, containing a tabulation of diversion-damage settlements by agreement (the same as Table 1 of this paper with a few exceptions), was upheld. To quote the opinion: "The publication of the details of settlement made with those whose properties were taken by eminent domain was not

TABLE 3.—POWER DEVELOPED, PURCHASED, SOLD, AND USED IN ELECTRIC BOILER ANNUALLY

	Millions of kilowatt-hours										
	Hydro power										
Year	Red Bridge	Ludlow hydro	Total hydro	Steam power	Purchased power	Total hydro, steam and purch.	Hydro sold	Steam power sold	Used by mill	Used by electric boiler	Mill use for power and light
1915	8.84	2.43	11.27	1.96	0	13.23	0	0	13.23	0	13.23
1916	11.82	2.54	14.36	1.68	0	16.04	0	0	16.04	0	16.04
1917	9.70	2.29	11.99	2.25	1.37	15.61	0	0	15.61	0	15.61
1918	9.09	1.39	10.48	2.14	1.74	14.36	0	0	14.36	0	14.36
1919	4.53	7.50	12.03	.05	1.56	13.64	0	0	13.64	0	13.64
1920	6.09	8.08	14.17	.02	1.54	15.73	0	0	15.73	0	15.73
1921	6.03	6.59	12.62	0	.53	13.15	2.03	0	11.12	0	11.12
1922	9.99	8.69	18.68	0	.08	18.76	4.70	0	14.06	0	14.06
1923	7.61	7.26	14.87	.64	.56	16.07	2.26	0	13.81	0	13.81
1924	5.53	5.57	11.10	1.11	.84	13.05	.41	0	12.64	0	12.64
1925	6.47	6.71	13.18	.91	.74	14.83	1.20	0	13.63	0	13.63
1926	7.04	6.59	13.63	.68	.66	14.97	1.67	0	13.30	0	13.30
1927	8.33	6.92	15.25	0	0	15.25	2.62	0	12.63	0	12.63
1928	10.39	5.94	16.33	0	0	16.33	2.74	0	13.59	0	13.59
1929	7.16	6.24	13.40	1.73	0	15.13	1.55	0	13.58	0	13.58
1930	5.97	5.81	11.78	1.36	0	13.14	1.32	0	11.82	0	11.82
1931	5.11	5.27	10.38	.36	0	10.74	1.67	0	9.07	0	9.07
1932	3.72	3.98	7.70	0	0	7.70	.15	0	7.55	0	7.55
1933	4.25	5.49	9.74	.30	0	10.04	0	0	10.04	0	10.04
1934	5.33	4.30	9.63	.04	0	9.67	0	0	9.67	0	9.67
1935	6.68	4.91	11.59	1.79	0	13.38	0	0	13.38	0	13.38
1936	8.22	7.59	15.81	.54	0	16.35	0	0	16.35	2.40	13.95
1937	15.42	17.47	32.89	.36	0	33.25	0	0	33.25	17.79	15.46
1938	16.01	14.06	30.07	0	0	30.07	0	0	30.07	21.61	8.46
1939	12.10	8.97	21.07	2.11	0	23.18	0	0	23.18	11.00	12.18
1940	8.96	8.09	17.05	2.17	0	19.22	0	0	19.22	6.50	12.72
1941	7.91	6.74	14.65	4.92	0	19.57	0	0	19.57	3.17	16.40
1942	12.14	10.93	23.07	2.69	0	25.76	2.54	0.68	22.54	6.72	15.82
1943	14.49	13.04	27.53	2.93	0	30.46	4.07	0.93	25.46	9.50	15.96

specifically required by law, and whether they should be included in the report was optional with the commission. Their inclusion in the report did not give them evidentiary value. Not all documents which have been prepared by a public official and filed in a public office and which therefore are in a sense public documents are evidence of the truth of the matters that they contain."

(5) During the trial the petitioner submitted seven deeds or releases, given to the Commonwealth by the parties with whom settlements had been reached by agreement, in each of which the amount paid was stated. These amounts, counsel for the petitioner contended in arguing before the court (in the absence of the jury) on the admissibility of the deeds, amounted in each case, after allowing for payment of the Ware diversion damage and interest on same, and discounting of the Swift diversion damage, to approximately $10,000 per foot head for the Swift diversion damage. The judge excluded the deeds, but did not state on what grounds. The opinion states: "We cannot say that, in view of the character of the proffered evidence, he was wrong".

However, the opinion goes on as follows: "As there must be a new trial . . . it is proper to discuss the questions that are likely to be presented with reference to the payments made by the Commonwealth to those other riparian owners and whether these payments may properly be shown as evidence of the value of the petitioner's water rights which were taken by the Commonwealth". The opinion then sets up four standards, all of which must be met, to permit the judge properly to admit the deeds in evidence, as follows:

(a) the water rights must be substantially similar;
(b) the takings must not be too remote in space or time;
(c) it must be shown that the transactions amounted in reality to a purchase and sale of water rights and nothing more;
(d) and that the sales were voluntarily and freely made.

(6) Exclusion of a certain lease was an error. This lease was not brought into the case when retried and need not be commented on here.

(7) Assessors' valuations were properly admitted in evidence.

(8) "There was no error in admitting testimony that persons interested in water developing properties would not be willing to invest

unless it appeared that a profit of ten or fifteen per cent would be yielded."

Ludlow Manufacturing Associates—Swift Diversion Case—Retrial

The retrial of this case was before Superior Court Judge Felix Forte in Springfield, April 12 to May 13, 1948. The pattern of expert testimony was the same as that of the first trial. The petitioner employed the same experts, both hydraulic and real-estate. One of the former had died in the interim between the trials, but his testimony in the first trial was read to the jury. The Commonwealth also had lost one of its hydro experts by death and put on another in his place. Otherwise the Commonwealth's experts were the same as in the first trial.

Testimony of the petitioner's experts was substantially the same as in the first trial. The figures of diminution in value were the same. On the other hand, in view of the ruling of the Supreme Court, the Commonwealth tried the case on the basis of full compliance with the War Department restrictions.

Counsel for the petitioner made strenuous efforts to obtain admission of the seven deeds or releases, given by various riparian owners to the Commonwealth with whom settlements of damages had been reached by agreement, seeking to show that the settlements satisfied the four requirements for admission specified in the Supreme Court opinion. Admissibility was argued by counsel of both sides at great length. They were not admitted.

An attempt to obtain admission of the 1937 report of the Metropolitan District Water Supply Commission, which the Supreme Court had ruled inadmissible, was also made. (This report contained a tabulation, showing amounts paid by the Commonwealth in settlements by agreement.) Subsequent to the handing down of the opinion a statute, Chap. 385, Acts of 1947, had been passed, which contained the following: "Statements of facts of general interest to persons engaged in an occupation contained in a list, register, periodical, book or other compilation, issued to the public, shall, in the discretion of the Court, if the Court finds that the compilation is published for the use of persons engaged in that occupation and commonly is used and relied upon by them, be admissible in civil cases as evidence of the

truth of any fact so stated". Counsel for the petitioner argued that this statute made the report admissible. Counsel for the Commonwealth argued that it did not. The judge, in the course of this argument, reasoned: "I think to come within this statute we must find as a fact that whatever the document is, a list, register, periodical, book or other compilation of general knowledge to persons engaged in an occupation, it is commonly used and relied upon by the members of that particular occupation and accepted by them as true". The petitioner then called in a consulting engineer, who testified that he knew "that other engineers do use this document and similar documents", and that such reports are commonly used and relied upon by his profession. After further arguments the judge specifically excluded page 9 of the report, which contained the table of settlements by agreement, and reserved decision on the admissibility of the remainder of the report. Since the only portion of the report of value to the petitioner's case was the table of settlements on page 9, nothing further was heard of the report during the trial.

As has been stated, the Commonwealth tried its case on the basis of the War Department restrictions; the petitioner on the basis of diversion under the Massachusetts legislation only, without reference to the War Department restrictions. The petitioner, through one of its experts, put in testimony to show the effect of the development of storage on the Connecticut River upon its flow and consequently upon the release from storage at Winsor Dam required by the War Department restrictions. This witness testified that the existence of these restrictions would not substantially change his figures for the difference in fair market values of the hydro plants, pre- and post-diversion; that the past flow records of the Connecticut from 1913 on were no measure of what might be expected in the future; and that, in consideration of future possibilities of storage development on the Connecticut, the effects of the War Department restrictions upon diversion "are likely to be reduced to practically zero".

Petitioner's counsel also called the chief engineer of the Metropolitan District Water Supply Commission and questioned him as to the extent of compliance with the restrictions subsequent to diversion in 1939. There had been none and the witness further testified that compliance in a strict sense is physically impossible, since the flow

of the Connecticut on any one day will not be known until the end of that day [the permit states that, on any day when the flow of the Connecticut is less than certain amounts, there shall be released certain amounts]. This statement was made use of by counsel for the petitioner in his argument and also in his unsuccessful attempt to have the War Department restriction excluded.

The jury, on May 13, 1948, brought in a verdict of $315,000. Since this amount included 35% interest, the award as of the date of diversion amounted to $233,333. This is $35,983 more than the award (as of the diversion date) in the first trial.

Discussion

E. Sherman Chase.* Much credit is due Mr. Sears for his laborious review of the many damage claims, settlements and litigation resulting from the diversion of the waters of the Ware and Swift Rivers. Previous data relative to water diversion damages have been published in the Journal of the New England Water Works Association, references to which will be found at the end of this discussion.

In approaching a consideration of the rights and wrongs in diversion damage claims, it is well to remember the following statement by Caleb Mills Saville, Hon. Member, NEWWA.

> "At the outset, it seems desirable to bring out a fact that is too often lost to sight in seeking reimbursement for damages from diversion of water for municipal purposes from a stream utilized for power or other uses; that, except in exceptional cases, the matter is one of corporation against corporation, or of individual against a corporation seeking only restitution, in money or otherwise, for the rights and property that are to be taken away. Too often this phase of the matter is overlooked in the pathetic or accusing eloquence that seeks to picture the municipality in the attitude of a timorous traveler set upon by highwaymen seeking to rob him of his rights. The fact is lost sight of that years before there was any dream of a vast population that would be requiring millions of gallons of water for its daily use, enterprising men established mills on these streams which were then in the wilderness, built villages, gathered stable and industrious employees and built up a community which enriched itself as well as made returns to the organizer of industry. In many cases this industry itself is the foundation of some community thriving because of the industry and obliterated if the industry is destroyed or seriously injured by external causes.

*Partner, Metcalf & Eddy, Statler Bldg., Boston 16, Mass.

"In problems between the individual and the city it is well to remember that not all the virtue is on the side of the municipality and that many an injustice in settlement has been committed because of unlimited resources in the common treasury disbursed by officials handling public funds as opposed by limited capital of the individual. Happily, however, this attitude is passing, and real values are now often given for sentiment, good will, and intangible injury to individuals; and fair and equitable adjustments are proposed for corporation rights."

All during the controversies over the damages for the diversion of the Ware and Swift Rivers, it seemed to this discussor that Mr. Saville's admonitions were quite thoroughly ignored by the representatives of the Commonwealth.

Space will not permit nor would it be worth while to attempt rebuttal of some of the implications contained in Mr. Sears' paper, but it may be desirable to point out certain features connected with the problems involved in the usurpation of riparian rights.

In view of the requirement that suits for damages should be filed within two years after actual diversion, most of the suits were tried during the depression years, when the industrial prospects for Massachusetts appeared gloomy indeed. It is interesting to speculate how the various juries would have reacted under the boom conditions of the war years or during the 1949 drought, when the tremendous importance of adequate water supply was publicized as never before.

Reference is made by Mr. Sears to the claims which were settled by agreement. It is significant that some difficulty was experienced in securing approval by the governor's council of the Collins Manufacturing Company's settlement, one of the proportionally higher awards. This fact illustrates the possible futility of attempts at negotiated settlements when political considerations may be involved.

The technical nature of the evidence and the difficulty of presenting such evidence to juries of laymen of assorted mental acuteness indicate the need for such cases to be tried before a special master or a selected board of auditors.

Mr. Sears gives the cost of the several trials to the Commonwealth but does not give the cost of preparation therefor. An examination of the annual reports of the Metropolitan District Water Supply Commission discloses the fact that preparation expenses for engineering, consultants, laboratory and other items amounted to over

half a million dollars, approximately 20% of the damages paid. No one knows the aggregate expenses to which the plaintiffs were put in negotiation and in litigation, but they must have been considerable.

Saville, in his paper previously mentioned, discusses at length the practice of compensation in kind where water rights are taken away. In this connection, it is worth while to cite the extent to which the Derwent Valley Water Board (England), which supplies water to Sheffield, Derby, Leicester and Nottingham, has gone to provide compensation water. This Water Board impounds the upper waters of the River Derwent in three reservoirs, having a combined capacity of 10,400 mil gal (Imperial), and diverts to one of these reservoirs water from the River Ashop. Works for the diversion of the River Noe are now under construction.

The total drainage area from which water will be diverted is 60 sq mi. The utilizable yield of this area is 62.91 mgd (Imp.). Compensation water must be let down at the rate of 17 mgd (Imp.) from the Derwent drainage area and at a rate of 3.75 mgd from the Noe area. Of the three reservoirs on the River Derwent, the lowest and most recently built, called the Ladybower Reservoir, was constructed largely to relieve the upper two reservoirs from providing compensation water. No data are available as to the cost of the Ladybower Reservoir but, in view of its capacity of 6,300 mg, formed by an earthwork dam 140 ft high by 1,250 ft long, it is evident that a substantial outlay was required to assure an adequate supply of compensation water. This compensation water from the Derwent catchment area corresponds to 0.4 mgd (U.S.) per square mile of watershed above the Ladybower dam. The estimated average required release of 12 mgd (U.S.) from the Winsor dam amounts to about 0.065 mgd per square mile of diverted area, which by comparison can hardly be called generous.

In the case of New Jersey vs. State of New York and City of New York, the Supreme Court of the United States in its decree stipulated that whenever the stage of the Delaware River falls below 0.5 cfs per square mile at either Port Jervis, N. Y., or Trenton, N. J., the City of New York must release from its impounding reservoirs on the upper Delaware River enough water to bring the flows at the points referred to up to 0.5 cfs per square mile. The City of New

York, however, is not required to release more than 0.66 cfs per square mile of the areas from which water is diverted. Again by comparison the letdown from the Quabbin Reservoir appears trivial.

It is also pertinent to recall that the late Allen Hazen proposed an 11,000-mg compensation reservoir on the Ware River, to offset 45 mgd of water to be diverted from the upper Ware above Barre Falls. The estimated cost of this compensating reservoir in 1926 was $4,800,000, a sum considerably greater than all the damage claims paid for both Ware and Swift diversions. This alternate program was not adopted.

Another indication of the value of water for sanitation purposes is provided by Senate Bill 579, enacted by the Massachusetts legislature in 1950, which provides for the payment to the Commonwealth, by benefited municipalities, of $10 per million gallons for water diverted from the Sudbury watershed into Lake Cochituate and thence into the Charles River. If this value were applied to the estimated average diversion from the Ware and Swift watersheds, the *annual* value of the water diverted from these two rivers would be about $850,000, which in only three years would approximate the sum total of all damages paid.

In view of the foregoing, it is obvious that the Boston Metropolitan Water District took over the riparian rights in the Ware and Swift Rivers at bargain prices, even though it cost the District a half-million dollars or so to accomplish its purpose.

References:

The Adjustment of Diversion Damages by Storage Compensation. Robert E. Horton, Jour. NEWWA, 1908, p. 334.

Report of Committee Appointed to Collect Data Relating to Awards for Water and Water-Power Diversion (Charles T. Main, Chairman). Jour. NEWWA, 1910, p. 1.

Report of the Metropolitan Water Supply Investigating Committee (House No. 900), Dec. 1, 1925.

Compensating Reservoirs and Diversion of Water. Caleb Mills Saville, Jour. NEWWA, 1926, p. 352.

Providence, R. I., Water Supply—Real Estate and Damage Settlements for 15,000 Acres Acquired for Scituate Reservoir. Earl C. Craig, Jour. NEWWA, 1926, p. 503.

The Law of Interstate Waters and Its Application to the Case of the Delaware River. Thaddeus Merriman and discussors, Jour. NEWWA, 1931, p. 199.
The Derwent Valley Water Board's Undertaking. Jour. Inst. Water Engineers, Aug., 1949, p. 391.
The Ladybower Reservoir. Harry Prescot Hill, Jour. Inst. Water Engineers, Aug., 1949, p. 414.

Substantiating data for certain of the petitioners' claims regarding the effects of diversion and other changes in the regimen of streams can be found in the following pertinent references:

Royal Commission on Sewage Disposal, 1913, 8th Report, Vol. II, Appendix.
Manganese in Impounded Water Supplies. Robert Spurr Weston and Arthur E. Griffin, Jour. NEWWA, 1933, pp. 40 and 280.
Providence Water Treatment. Elwood L. Bean, Jour. NEWWA, 1935, p. 406.
A Ravished River Glimpses Glory. Arthur L. Shaw, The American City, May, 1937.
The Natural Purification of River Muds and Pollutional Sediments. Fair, Moore and Thomas, Sewage Works Journal, 1941, pp. 270, 756 and 1209.
Stream Sanitation. Earle B. Phelps, 1944, p. 119.
Water Quality Requirements for New England Industries. Hervey J. Skinner, Jour. NEWWA, 1938, p. 403.
Progress Report of the Committee on Quality Tolerances of Water for Industrial Uses. Jour. NEWWA, 1940, p. 261.

HOWARD M. TURNER.* This is an interesting paper, describing in considerable detail the various damages paid for riparian rights on the Ware and Swift Rivers. It is well to preserve a record of the various transactions and payments made. It is difficult to discuss the paper without going into similar detail from the petitioner's side, but it hardly seems worth while to try the cases all over again in the JOURNAL of the N.E.W.W.A. However, from the point of view of the petitioners, in connection with the water-power damages there are certain exceptions and comments on the paper that should be noted.

In his discussion, E. Sherman Chase gives a quotation from Caleb Mills Saville's paper on the subject of damages due to water takings. The writer echoes Mr. Chase's comment on the attitude of the Commonwealth in these cases, as compared to the ideal expressed by Mr. Saville. The abuses which Mr. Saville mentioned are intensified when the Commonwealth and not a municipality is the party. This

*Consulting Engineer, 6 Beacon St., Boston 8, Mass.

public-use angle, which was well emphasized in the trials by the State, is more potent now than formerly, with government rights assuming greater importance all the time than the private rights of an individual or a corporation.

The writer also feels that Mr. Sears implies that many of the water-power claims made by the owners in the court cases were excessive. It does not apparently occur to him that perhaps the Commonwealth's figures were too low to give adequate compensation for the power taken.

The author points out that the Commonwealth first used real-estate experts, as compared to engineers, to testify to the water-power damages. He states that "real-estate experts are not water-power experts and water-power experts are not competent to evaluate real estate". The writer agrees with the first part of the statement but differs strongly from the second. He has made valuations of something over 100 water-power properties for all purposes, including purchases and sales, including the real estate involved. Many of them were for the "land and water rights"—i.e., the real estate only. The author seems to have no doubts about the character of the testimony of these real-estate experts, which, if correct, means that all of the larger settlements on the Chicopee River, made by the Commonwealth under the advice of their own engineers in advance of the taking, were 8 to 10 times too big. In the first case in which this type of testimony was introduced, the water-power engineers were present when the trial opened and apparently were going to testify. They were prominent and competent engineers, who had been employed by the Commonwealth as consultants at the time when various settlements were made and had appeared as witnesses in previous trials. Based on their previous testimony in other cases, their figures could not have helped being very much in excess of the figures put in by the real-estate experts, which probably accounts for the decision to use the latter. The writer believes their testimony would have given a fairer basis for the jury than the kind of testimony put in by the real-estate men.

Most of the writer's comments can be illustrated by referring to the case of the Ludlow Manufacturing & Sales Corp. for diversion of the Swift River, which will be discussed in some detail. The author devotes considerable space to this case. The Ludlow company owns

Chicopee River Plants

Company	Net drainage area (sq mi)	Head (ft)	Total paid	Settlements for Diversion — Estimated for Swift River only* — Without allowance for interest and discount: Total	Per foot head	With allowance for interest and discount†: Total	Per foot head
Indian Orchard Co.	667	34.0	$375,000	$333,333	$9,804	$408,981	$12,029
Quinnehtuk Company—							
Bircham Bend	684	14.5	140,000	124,444	8,582	161,383	11,130
Chicopee Mfg. Co.	694	25.0	250,000	222,222	8,889	285,752	11,430
Dwight Mfg. Co.	698	30.0	225,000				
Dana S. Courtney			10,000				
A. G. Spalding and Bros.			12,000				
Ames Sword Co.			2,500				
			$249,500	221,778	7,393	303,807	10,127

			Figures Used in Swift River Damage Suits — Petitioner's claim: Total	Per foot head	Commonwealth's claim: Total	Per foot head
Ludlow Mfg. & Sales Corp.						
Red Bridge Plant	644	48				
Ludlow Plant	667	41			$118,000	$ 1,326
Total		89	$725,000‡	$8,146	95,000	1,067
Palmer Mills	633	27	223,000	8,259	24,000	889
			185,000	6,852	21,246	788

*Estimated Swift River damages are separated from the Ware River damages on the basis that the amount of power diverted by the Ware River taking was 12½% of that diverted by the Swift River taking.

†Estimated by taking interest from date of Ware River taking to date of deed and discount from date of deed to date of Swift River taking.

‡Engineer's testimony as to diminution of market value of water power was from "not less than" $600,000 to $822,000.

the two largest of the eight water powers on the Chicopee River, five of which powers were settled by agreement. The accompanying table shows the total figures for which four of these settlements were made. The Collins Co. settlement is not included; it was on a much higher basis but probably included some pollution damage. It was testified in the Ludlow case that the power diverted by the Ware River taking was 10% to 12½% of that of the Swift taking. Based on the latter figure, the total settlements have been divided between the Ware and the Swift, first without any allowance for discount for advance payment of the Swift River damages and interest for late payment of those for the Ware River. The Swift River figures are then expressed per foot of head, varying from $7,393 to $9,804 per foot of head. (It should be noted that the value per foot of head should decrease downstream as the drainage area increases, so that the drainage area diverted becomes a smaller part of the total.) Figures are also given for the same settlements with allowances for interest and discount. These range from $10,127 to $12,029 per foot of head.

The table also shows the figures given in the testimony of the trials of Ludlow and Palmer Mills Swift River cases, the only two remaining companies with water powers on the Chicopee River. These show that the petitioners' claims were $6,852 to $8,259 per foot of head—all less than any of the above figures for the settlements, except that of the Dwight Manufacturing Co.—whereas the State's real-estate experts' figures are from $788 to $1,326—in the neighborhood of 1/10 of the settlement figures.

Another measure of the validity of the State's real-estate men's figures is the testimony in the Palmer Mills case. The Ware River diversion verdict in the Palmer Mills case was $24,686. As noted above, the Ware diversion is 1/8 to 1/10 that of the Swift diversion. As shown in the table, the State's real-estate experts testified to values for the Swift of $21,246 to $24,000, or less than the above verdict for the Ware River alone.

It was unfortunate that these settlement figures could not be got into evidence, though every possible effort was made by counsel for the petitioner. On the question of whether the "sales" of the Swift River diversions settled in advance were free sales, the petitioner put on as a witness a former member of the Metropolitan District

Commission when the settlements were made, who testified that in his opinion the sales were free, and the State had another member and former chairman of the Commission at the time, who testified that in his opinion they were not "free and voluntary", on account of the fact that the taking by condemnation was available.

In describing the re-trial of the case after the appeal, the author states that the petitioner employed the same experts. As a matter of fact, the petitioner used another water-power expert, who testified to a value for the diversion of the Swift River as $702,000, which he arrived at as 90% of the total for the Ware and the Swift both. This was a prominent water-power engineer, whose firm had arbitrated and advised the Commonwealth in the settlement of many cases in prior years, and whose firm has also been frequently employed by the Ludlow company.

The question of the so-called War Department restrictions deserves a word. The State has the right to take water at all times from the Swift River and during certain months from the Ware, but it can take it during all months from the latter by order of the State Department of Public Health. The decision in the case of Connecticut versus Massachusetts required that the War Department regulate the diversion of the water of the Swift River. These War Department restrictions require that on any day when the flow of the Connecticut at Sunderland, Mass., is less than 4,900 cfs, there should be let out from the Swift River 70 cfs, and when it is less than 4,650 cfs, 110 cfs. The question of whether these restrictions should be included in reducing the damages in the Ludlow case was ruled upon by the Supreme Court on appeal, which held that they should be. Evidence was brought in that they never had been observed. One of the Commonwealth's engineers testified that in his opinion they could not be. Apparently the Commonwealth never made any attempt to observe them, nor the War Department any attempt to enforce them. As a matter of fact, they are not being observed today. Apparently the only recourse that the water users on the Chicopee River have for the water thus diverted and not paid for in these awards is to file suits from time to time for the damages suffered.

Closing Discussion by Mr. Sears

Both Mr. Chase and Mr. Turner seem to feel that the Commonwealth showed little regard for justice to the petitioners. Perhaps that charge is justifiable in the cases tried. On the other hand, the same charge can be made with considerable truth with respect to much of the testimony introduced by the petitioners. With respect to the cases settled by agreement, however, there was never, in the writer's opinion, any attempt or intention to force unfair compensation on any of the parties affected by diversion. There was, rather, an honest attempt by both sides to agree upon a figure fair to both and the payments made in those cases seemed to satisfy both parties.

Court trial before a jury, however, presents a totally different set-up. Instead of an effort to reach an agreement there is, in such a trial, a striving by each side to impress a group of "laymen of assorted mental acuteness", as Mr. Chase aptly puts it, with favorable figures. Inevitably both sides stretch the imagination to the limit—perhaps unconsciously—with the result that the petitioner presents claims and estimates which to the respondent's representatives appear exorbitant, and vice versa. The trial is a competition with no holds barred.

Trial by jury in cases of this kind is not, in the writer's opinion, the best way or the way most likely to obtain equitable awards. Trial before a special master or board, as Mr. Chase suggests, is more likely to produce satisfactory results. It is, perhaps, significant, however, that the petitioners chose trial by jury.

With regard to the use of real-estate experts to give estimated pre- and post-diversion fair market values, Mr. Turner states: "The author seems to have no doubts about the character of the testimony of these real-estate experts." If, by that, he means that the writer believes that the approach to the determination of damages used by those experts is the proper one, he is mistaken. The writer does not so believe. He clings to the time-honored method of evaluating the power lost by diversion in an average year, capitalizing at rates adapted to the degree of speculation involved in the assumptions made, and considering the result as the damage sustained.

The difficulty with that method in court in Massachusetts is

that the law defines the damage as the difference in the pre-diversion and post-diversion fair market values of the real estate, and the Court instructs the jury that testimony as to the value of the power before and after diversion is to be taken into consideration only as an element in arriving at fair market values and that testimony as to pollution claims should be similarly considered. Such instructions are apt to be confusing to the jurors, who want to hear direct testimony as to the fair market values before and after diversion.

The real-estate experts, employed by the Commonwealth in the Boston Duck Co. and subsequent cases, gave them such testimony. As to the method employed by those experts in estimating fair market value, which starts with estimating annual gross income from the property, based on rental of the floor space of a mill, designed and operated for a specific type of manufacture, the writer does not and never did consider it rational or reasonable. It is doubtless correct as applied to an office building, warehouse or even a vacant mill property, but to apply it to a going mill does not seem logical.

THE REQUIREMENTS OF A PIPE JOINT FOR WATER LINES

BY ARTHUR HICKS*

[*Read September 15, 1949.*]

THE wise choice of a pipe joint depends upon a number of important considerations. While some of the factors to be taken into account are immediately obvious, there are others that may easily escape evaluation. The purpose in this talk is to present a "check list" of the qualities of a satisfactory pipe joint for water lines, all sides of the question being kept in mind.

In general, pipe joints on water lines should have the following qualities:

1. The joint must assure permanent tightness.
2. The joint must provide flexibility.
3. The joint must afford simplicity in construction.
4. The joint must have strength equal to that of the pipe.
5. The joint must offer real economy in construction and maintenance.

Each of the above qualities and features, essential in a completely dependable and satisfactory pipe joint for water lines, will be discussed below.

I. PERMANENT TIGHTNESS

The first and most essential quality that any type of pipe joint must possess is tightness. It must be tight on first test and stay that way through all the service life of the water line. Unless it meets these requirements, the joint is not satisfactory, and to use or purchase it at any price may turn out to be a waste of money.

Water is no longer a cheap commodity. Among all water-works men there is an increasing lack of tolerance of "unaccounted-for" water. The rapid increase of populations and per-capita use of water plus the high cost of developing new sources, pumping, filtering, treating and general operations make it imperative that water systems

*Dresser Manufacturing Division, Dresser Industries, Inc., 1523 Widener Bldg., Philadelphia 7, Pa.

operate at top efficiency. Water losses through joint leakage of even a few thousand gallons per day are often serious, not only through loss of supply, but through expensive repairs and possible damage suits. The use of joints known to be tight is therefore essential.

The water industry, conservative, with a long history of trial and error behind it, was slow to adopt mechanical couplings as a means of joining pipe. But starting shortly after the first world war, the mechanical coupling was tentatively and then enthusiastically used, until, at the present time, it is probably an understatement to say that 75% of all water systems have at least one and, in many cases, thousands of mechanical couplings in their lines.

The reason why mechanical couplings offer exceptional tightness is not hard to find. A thoroughly proved design and a positive gasket-pack account for it in part. Accurately made standard parts and simple, fool-proof assembly are other factors.

The heart of every mechanical joint is, of course, the rubber gasket. Many people do not know that this gasket is not just rubber. Raw rubber, naturally, forms the basic ingredient, with as many as ten other substances blended to provide the optimum of stability, resilience to provide pack, and other qualities known to be required for long life. It is of advantage to know that water has proved to be a good preservative of rubber. The design of the gasket in a roughly triangular shape, with generous cross-section to insure pack, is also important in assuring a tight joint. Service life of gaskets may be assumed to be infinite, since little change takes place after final tightening of the joint. Cases on record date as far back as 60 years and show an undisputed state of preservation and retained resilience.

Metal components also contribute to the permanence of mechanical joints. The middle ring must be as strong as the pipe itself. To assure this, Barlow's formula is used with a safety factor of two in designing the middle ring. Expanding the middle ring to exact size results in a cold working of the metal, which actually increases its strength. Bolts have rolled threads, with the threaded portion testing stronger than the shank itself.

In summary, therefore, tightness is important in modern pipe joints. In mechanical joints tightness is assured through time-tested design, the best of materials, and precision manufacturing.

II. Flexibility

Good engineering practice approves flexibility in a pipe joint, for the same reason that nature also demands flexibility in practically all man-made structures that are subject to natural forces. Failure to provide this necessary degree of flexibility in a pipe line often accounts for many of the breaks and leaks that occur, and for subsequent high maintenance costs. On the other hand, the use of properly designed flexible joints—capable of absorbing many of the stresses that cause failures in rigid lines—protects all parts of a pipe line against harm. Thus, the pipe-line operator who uses flexible joints is automatically carrying insurance against excessive leakage losses and costly repairs, against damages to property caused by line breaks, and against the sometimes serious losses incident to service interruptions.

Strictly speaking, a pipe joint cannot be called flexible unless it will absorb, without leakage or harm, all ordinary stresses set up while the line is being laid, as well as movements of the pipe after the line is in service. Every pipe line is subject to longitudinal stresses, caused by expansion and contraction, the amount of movement depending upon the temperature range within which the line operates. Mechanical joints absorb movement up to ⅜ in. per joint—thus preventing the building-up of expansion-contraction stresses.

Other stresses also affect a pipe line after its installation. No matter how carefully the line is laid, it is virtually impossible to install it perfectly straight or level, for ditches are hardly ever exactly uniform in depth and the backfill is never equally distributed nor evenly packed. Furthermore, most ground is subject to shifting and settling at one time or another. Vibration is another very harmful condition, especially in cities, where street traffic, railroads, manufacturing plants, and buildings under construction are constant sources of severe shock. Many thousands of dollars are lost annually because of leaks and breaks in buried water lines—losses directly traceable to vibration.

A pipe line is affected by these different kinds of external forces in direct proportion to its rigidity—fatigue and failure always occurring more quickly where the type of construction causes the stress to be localized or concentrated.

III. Simplicity

Pipe lines are laid under widely varying conditions—across deserts, in arid and tropical climates, over mountains, on bridges, under rivers, through swamps, in cities, during all seasons of the year, and in different types of soil. Unless the joint is one that can be easily and quickly completed under any or all field conditions, serious construction problems are encountered.

The "human equation" greatly influences the quality of the work done in the field, even by experienced workmen. Thus, the pipe joint that can be assembled in the field by ordinary labor, without complicated accessory equipment, simplifies construction work and helps eliminate field supervision difficulties.

Simplicity of design and installation in a pipe joint also materially decreases total laying time of the line. Crews are kept small, well bunched and manageable. Often the construction speed of a line is retarded by a single slow joint-making operation. Speed of installation also directly affects the total cost of the line (including interest charges during construction) and is of the utmost importance to both the contractor and the owner. Speed becomes of even greater importance when it concerns placing of badly needed facilities in service as soon as possible.

In a very practical sense, mechanical couplings are "factory-built" and are merely assembled, not made, in the field. The coupling parts are standard and interchangeable, and are carefully fabricated from high-grade materials in the factory, where modern equipment, trained workmen and advanced engineering function together under ideal conditions. The result of this method of manufacture is "built-in" simplicity—permitting a degree of accuracy and uniformity in jointing that is impossible with joints that are fabricated or made in the field. Ordinary laborers, after only a few brief instructions, can quickly assemble the parts of a mechanical joint so that it may be depended upon for uniform and lasting efficiency.

Pipe-joint simplicity has its greatest importance while a pipe line is under construction. Those who have witnessed the laying of a mechanically jointed line will undoubtedly recall how smoothly and uniformly the work progressed. Field operations are reduced to a minimum and proceed like clockwork. Each man has a full-time job.

There is hardly any waiting or "lag" between operations. If desired, assembly can be carried on economically from several points. No long lengths of trench need be kept open—which is a special advantage through heavily traveled districts, or where local ordinances limit the length of trench and the time it may be kept open.

Coupled lines can be laid in any kind of weather, in wet ditches, above or in the ditch, or even under water. Backfill can be started as soon as assembly operations are completed.

The middle ring and followers of the coupling assist in lining up the pipe and, after the coupling parts and the pipe are once in position in the ditch, the only remaining operation is to insert and tighten the bolts.

Ease and speed of installation are vital necessities in modern pipe joints. Mechanical couplings offer probably the easiest, simplest and most effective way of joining pipe in use today.

IV. Strength

The strength of a pipe joint is not an incalculable quality; in most cases, it can be determined precisely by mathematical formula and by test. Couplings, being built of standard, interchangeable parts, can be made—through selection of the proper parts—to hold safely any specified working pressure. In passing, I should like to mention some 75⅝-inch O.D. Dresser couplings, which were designed for a penstock in British Columbia. These couplings operate safely at pressures up to 1300 psi. It has been demonstrated that, for all practical purposes, a coupling, properly installed, will remain tight up to the pressure required to stress the steel in the middle ring beyond its yield strength. In other words, the pressure rating of a coupling may be based upon the strength of the middle ring, which can be definitely varied to meet different working pressures successfully, by altering the thickness and physical properties of the metal used in it. With the middle ring as the controlling factor, the followers are designed to provide a corresponding and adequate packing pressure, and the gaskets and bolts are proportioned in such a manner as to produce a carefully engineered joint of well-balanced design, with highest ratios of strength to weight, and of strength to cost, in all parts.

Manufacturing tolerances within narrow limits are followed, in

order that the various coupling parts will fit perfectly. Rigid specifications control and maintain the predetermined yield and ultimate strengths of all raw materials.

The thickness of the middle ring required for a pipe line of given diameter, operating at a given pressure, is calculated by Barlow's formula, as follows:

$$T \text{ equals } \frac{PD}{2S} \qquad \text{or} \qquad P \text{ equals } \frac{2ST}{D},$$

where T equals thickness of middle ring in inches;
P equals working pressure in pounds per square inch;
D equals outside diameter of middle ring in inches;
S equals allowable working stress in pounds per square inch.

The value of S depends upon the factor of safety and the physical properties of the steel. It has been customary to base the working stress upon the ultimate strength of the steel, with a suitable factor of safety.

Where working pressures are low and light-wall pipe is used, the strength of standard couplings is considerably more than required. Special couplings are, therefore, supplied for light-wall pipe.

V. Economy

In the planning of a pipe line, the engineer aims to arrive at dependable cost estimates, for, if the anticipated costs are exceeded, the return on the original investment will be correspondingly reduced. Maintenance expense also must be provided for and, if the sums spent for this purpose are greater than the amount originally allotted, further reductions in the net return must necessarily occur.

It is a common mistake to regard the cost of a pipe joint as being made up of two elements, namely: (1) the cost of pipe-joint materials and (2) the actual field labor cost of assembling or making the joint. These two elements of cost are easily obtainable and are of value where quick estimates are desired, but the "true pipe-joint cost", in addition to raw materials and labor, involves a number of other elements. It includes, among other things, the following:

1. Expenditures necessary to provide special tools and accessory equipment, required to fabricate certain types of joints.
2. Influence of joint-making on the speed and cost of other laying operations, including interest during construction.
3. Outlays for repairs and maintenance of joints after installation.
4. Damage to property or loss of life, due to joint failures.

Economy in pipe joints, then, does not mean merely a lower first cost. It means a lower joint cost during the life of the pipe line, everything considered. The "true cost" deals with the future, as well as the present, and is the only reliable measure of economy.

Material expense in a pipe joint is the sum of the cost of preparing the pipe ends at the mill plus the cost of the material used in the joints. Where special fittings, layouts, etc., can be eliminated by the use of flexible joints, the resultant savings should be credited to the advantage of such joints, whenever comparison is made.

Installation expense includes all costs incurred in either making or assembling the joint in the field. It should include a charge for any accessory equipment that is necessary to complete these operations satisfactorily. The cost of special supervision, if this is necessary in order to help assure the making of uniform joints, is also a part of the installation cost.

The speed of assembling or making pipe joints in the field usually affects the speed, efficiency and cost of other construction operations. Where such other operations are adversely affected by the use of a particular type of joint, this extra expense, although not apparent, should be considered a part of the true pipe-joint cost.

Strictly speaking, the true cost of a pipe joint cannot be accurately determined until after the line has completed its service. During the life of a line the repair and maintenance of joints may vary within wide limits, depending upon the type of construction used. In some instances, this expense has become a very significant part of the operating cost and, if due to defective or inefficient joints, it may rightly be considered as an element in the cost of the pipe joint.

High leakage losses, service interruptions and damage to life and

property, in addition to repair costs, are the natural consequences of joint failures. While these items are considered as indeterminate at the time when the pipe line is being built, comparative performance records show (1) that one serious failure may involve many thousands of dollars and (2) that serious losses, chargeable to joint failure, can be almost wholly prevented by the use of the proper type of joint construction.

The low material and installation cost of a properly designed mechanical joint assures speedy pipe-line construction at low first-cost. The plain-end pipe used is less expensive than pipe with specially prepared ends. Many special fittings are eliminated by the flexibility of the coupling. Investment in, and maintenance, fuel and transportation costs on, expensive jointing machinery are not required. Ordinary labor may be employed. Jointing cost per linear foot can be estimated closely in advance. Faster completion of the line—made possible by speedier joint installation—reduces total construction costs.

Conclusion

In conclusion, I should like to call your attention to the fast-growing record of mechanical couplings in water service. Leading consulting engineers and the engineering departments of America's largest cities and thousands of smaller cities have not failed to recognize the outstanding advantages of this truly modern type of construction. As of today, the only reason that mechanical couplings cannot claim to have celebrated their hundredth birthday is that they weren't born that long ago. Neither was television or the atom bomb.

PRESSURE FILTRATION

BY ERNEST E. TANKARD*

[*Read September 16, 1949.*]

PRESSURE filtration is a closed form of rapid filtration, placed in a high-pressure pipe system and thus operated under pressure. The filters are built in the form of steel cylinders—the smaller sizes with an axis vertical and larger sizes with an axis horizontal. Details of strainer system and wash-water appliances are similar to those used in the gravity type. The advantage of the pressure type is the saving in pumping cost, especially where it can be installed in a gravity supply. The chief disadvantage is the fact that its action cannot be directly observed. Observation is usually made through a small manhole cover on the top of the cylinder.

In Berlin we have eight cylinders, 18 ft 6 in. long and 8 ft in diameter, set up horizontally. The static pressure before filtration is about 90 lb.

Each filter unit has 15 cu yd of concrete in the bottom, covering a network of 2-inch wrought-iron laterals. One hundred forty-four brass strainers comprise the underdrain lateral system, to insure distribution of the back-wash water and uniform collection of filtered water. Directly above the strainers is a four-inch brass air-wash manifold, running the entire length of the filter shell. To this is connected, at right angles, a brass piping system of ½-inch pipe on 6-inch centers. These small pipes are perforated with 1/16-inch holes. The tanks are filled to within 27 in. of the top with "anthrafilt," a substance manufactured from anthracite coal. There are six different sizes, varying from nut coal in the bottom to a size of 0.5 mm at the top.

Each of the tanks is a complete filter unit in itself and can be operated separately, if desired. They are designed to operate at 2 gal per min per sq ft of surface area. Back-washing is done with filtered water plus bubbling air through the filter bed, to accelerate its action. The plant was put into operation in September, 1939. Although prac-

*Superintendent of Water Works, Berlin, N. H.

tically no color is removed, excellent results have been obtained in the removal of solid matter. Sediment removed by this process often reaches as much as 10 cu ft per mil gal filtered.

Since filtering water was something new in our department, we had many problems with which to contend. Dampness during the first year of operation was so great on the outside of the tanks and piping that oftentimes the entire floor would be wet. After six months of experimenting with various types of insulation, it was finally found that granulated cork would eliminate the trouble. About ⅜ in. of this substance was used on the tanks and piping. Since that time there has been no trouble whatsoever from dampness in the building.

About three years of successful filtration were enjoyed. Beginning in 1942, however, there always remained a constant head loss after the beds were washed. Continuous back-washing would not eliminate the trouble. An inspection of the filters disclosed about six inches of the fine material on top of the beds as perfectly clean, but below this depth—especially on both sides, to a distance of 12 in. from each side towards the center—the filter material was thickly caked with a solid mass of sludge, mixed with the anthrafilt, through which it was impossible for water to filter. Observation of the anthrafilt through a microscope disclosed a heavy growth of algae around each grain.

An overnight experiment showed that sodium hypochlorite and water, having a strength of 40 ppm, would remove the algae without attacking the anthrafilt. We therefore proceeded on this basis and, after several treatments, again inspected the beds. We found that about five feet of the eight-foot surface area was perfectly clean, but both sides were still impregnated with sediment and showed very little improvement from treating and back-washing.

As an experiment, a piping system with 7/64-inch holes at 12-inch intervals was constructed and set up inside one of the filter tanks, the purpose of which was to discharge a jet of water at a 45° angle directly into the solid mass around the sides of the tank. With a jet velocity of 107 ft per sec and the back-washing of 440 ft of air per min, an agitating movement was set up in the solid mass, breaking up the anthrafilt and sediment. Fifteen-minute agitation of this type was used, after which agitation was continued for another 15 min with air only. Then the usual water-wash method was used. Three treatments like

this were given No. 1 filter, after which an investigation of the bed itself was made. It was found that the entire bed was as clean as the day it was first put into service. The experimental unit was then removed and a permanent unit of similar construction set up inside each filter unit.

Back-Washing of Filters

Back-washing intervals of filters from date of installation varied from daily washings in low-water periods to as much as three weeks in the winter-time. In 1945, or six years after installation, we began to receive complaints of fine coal in flush-tank valve seats. Investigation disclosed that the fine anthrafilt was coming through the filters. Further investigation showed that the fines had become mixed with the coarse grades in all units.

This was a real problem and of course meant the temporary discontinuing of the filter plant. We got around this situation by installing a twin set of Elliott strainers in the main distribution line, so that we could still use the filters. Then we proceeded to remove the filter material from each tank. The material was all regraded, washed and replaced in each unit. About twenty tons of the 0.5-mm size, or the finest grade, had been discharged into the piping system. We have since felt that long periods between back-washings were poor practice and attributed our trouble to these long periods between washings.

As time went on and the demand for more water increased, back-washing of filters became a heavy load upon the units, due to the use of filtered water, taken directly from the effluent of the filters. During periods of heavy draft, night washing was necessary. In 1947 an elevated tank was erected behind the filter plant for wash-water purposes. Filtered water is supplied to this tank from the filtered-water line during periods of minimum draft. Now, therefore, after ten years of pressure filtration, we feel that our preliminary troubles have been eliminated.

TELLING THE PUBLIC ABOUT "WATER"

BY MARTIN E. FLENTJE*

[*Read September 16, 1949.*]

ALMOST every water-works man is sooner or later called upon to make a talk, either on his own company's or department's water supply or on the more general subject of "Drinking Water." Such a request often cannot readily be rejected and then begins a search for material to present. It soon becomes apparent that there is no lack of interesting material in any water works—the problem is one of deletion and choice and then presenting the chosen items in a way that will be interesting to the audience. The author of this paper has had to present a fair number of these talks and he hopes a brief outline of what he has found useful will stimulate others to tell of their findings and experiences.

Every water-works man must be impressed, if he stops to think about it, how little the average citizen knows about the water-works business. Few people realize, for example, that water, as we know it, varies in character almost as much as do people—so much that the terms "Hingham water" and "Dedham water" represent as much difference as do your neighbors, Brown and Smith. Yet in both Hingham and Dedham, the public water supplies are, to the chemist, 99.9% or more H_2O and that small 1/10 of 1% of dissolved minerals makes all this difference—and of course these remarks need not be confined to Hingham and Dedham. In very few supplies is the mineral matter, dissolved in the water, sufficiently alike so that some difference in water character is not noticeable.

Few men realize also that for a water-works to do business requires an investment of cold cash much larger in amount than almost any other business. This investment of $70,000 per employee compares with the $6,000-$7,000 invested for each employee of an industrial concern; per customer served, the difference is even more striking. Rather than attempt to summarize other such facts, a brief outline of

*Research Engineer, American Water Works Co., Inc., 121 South Broad St., Philadelphia 7, Pa.

the talk, followed in general by the author, is given below. The only excuses for offering it are that it is the results of some testing and that it is hoped that presenting it will bring forth other experiences.

GENERAL OUTLINE FOR TALK ON "WATER"

General.

Approximately 1/3 of the talk is devoted to general information about public water works and supplies, number in the United States, people served, investment, history, etc.; 1/3 to "water as a chemical compound", including a very elementary, chemical, color-changing "magic" act; and finally 1/3 to the local water supply and company, its purification and treatment plant and problems, the distribution system, special problems, organization, etc.

First Third of Talk—General Information

Interest needs to be captured and stimulated right at the beginning of any talk, and the writer has found that the following simple statement does this quite well: "You may not realize it, but you all probably know the best-known water-works man in the United States —even though actually he isn't a water-works man at all! I am referring to radio's Throckmorton P. Gildersleeve, the Water Commissioner of Somerfield"—and then going on from there. If Gildersleeve were making this talk, he might carry on by first giving his listeners some water-works history.

History

He might recite some of the many historical facts, such as: the first water works in the United States was the one constructed in Boston in 1652, 32 years after the Pilgrims landed and 22 years after the founding of Boston itself. The second was the one in Schaefferstown, Pa., and the third, the works in Bethlehem, Pa. In Schaefferstown, the original owner bequeathed the works on his death to the property owners of the borough and, as owners, they were to get their water for the sum of ten cents a year. All others were to be required to pay fifty cents! Growth of the industry was slow; in 1800 there were only 16 public water works (15 privately owned and 1 publicly owned) and the number did not reach 100 until 1850. In 1875 the number was 243, but rapid increase in numbers took place right after this, the number

reaching 1,000 by 1885, 3,000 by 1895 and 9,000 by 1924. At the present time there are more than 12,500 public water-works organizations in the United States, serving approximately 85,000,000 of the nation's citizens.

The industry's income is approximately $500,000,000 per year, which places it between "job printing" and "creamery butter" businesses. Employees number close to 80,000 and much can be said about the average years of service of these people. The total investment in water-works properties is over $5,000,000,000. (These and many more statistics are given in an A.W.W.A. publication—*Nuggets for Water Works Speakers.*)

Water from a Chemist's Viewpoint

Gildersleeve would probably have difficulty in keeping from "showing-off" his chemical knowledge and water is a good subject for such a display. Indispensable to life, water is also indispensable to a large number of manufacturing industries, because many chemical reactions would not proceed without it. People rarely think of water, except when it becomes scarce during drought periods. But even in severe droughts we can be consoled by the fact that water is very abundant—so much so that, if all the world's mountain peaks were leveled off and the valleys filled in, there would still be sufficient water on the earth's surface to cover it all to a depth of two miles! Its chemical formula of H_2O shows water to be made up of hydrogen and oxygen —both elements that usually exist as gases and one of which, hydrogen, is extremely explosive, while the other, oxygen, must be present for most explosions to occur; yet the two combined form the most commonly employed fire-extinguishing agent. Water gets heavier as it gets colder, but suddenly reverses itself in this characteristic and, as it cools below 39.6° F., actually becomes lighter. This fact is extremely important, for if water continued to gain weight on cooling below 39.6°, ice would form from the bottom of streams and lakes *upward,* instead of downward as it now does, and would result in huge blocks of ice, glaciers and unbearable climates.

To deviate from this fare of facts, the writer at this point does a few simple color-change feats of magic. Water, made alkaline with caustic soda, becomes "wine" when poured into a glass containing

phenolphthalein indicator, and colorless again when poured into a glass containing a few drops of acid. If dosed beforehand with a chlorine compound, the "wine" can be poured into a glass containing orthotolidine and become a yellowish-orange color. Simple though these reactions are, they can be used for entertainment and as a basis for remarks about the alkaline character of the supply, corrosion-prevention treatment with lime or soda ash, and the protection offered by chlorine and the control of this treatment through the regular tests made by the department's operators.

Discussion of Local Company and Plant

At this point the listeners would probably like to have Gildersleeve get down to the local situation. The writer has found that too much detail in this description is boring and wasted, but unusual aspects or an exceptional record of satisfactory bacteriological results, for example, are of interest. Storage, chemical treatment and filtration can be readily explained. A Venturi or other meter chart, showing the variations of flow to the system throughout a 24-hour day, can be used to demonstrate the character of certain systems. People in an industrial city, for example, will start rising considerably earlier (and retire earlier) than those of a commuting area; that men go home for lunch shows up in such a record, and the time of arrival of the men from work during sprinkling periods shows up quite plainly (as does occasionally a slight increase in rates of flow around 2 or 3 a.m., which can be used for the injection of humorous remarks).

Finally, the occasion should be used for a little boastful or "prideful" discussion about the industry's part in improving health. The typhoid-fever records of this country are a remarkable record of preventive medicine and we have a right to be proud of our part in the conquest of this particular disease. We should be proud of our service, because in what other industry are interruptions in service so rare, particularly in a 24-hour-a-day, 7-day-a-week industry? And finally, where else can your listeners buy a "manufactured", treated, laboratory-controlled, quality-tested product at any such low cost figure as ten cents a ton (or less)—the average charge we make for water?

Discussion

Linn H. Enslow (New York, N. Y.). I should like to put in one plug, if I may. Mr. Flentje's paper mentioned the *Nuggets for Water Works Speakers,* published by the A.W.W.A. I want to say that that is a very valuable reference, when you are getting ready to make any sort of talk on public water supplies, because what A.W.W.A. has done is to collect the information from here and there and put it together in a very condensed form, and it is easy to use.

I do want to say this, that there is one error in it, and you should know it. There is a claim in there of the date of the Boston water supply, which is in error. The Boston public water supply, so far as I know, is the oldest public water supply in the country. I believe Schaefferstown, or some other place, is offered as being earlier. I do not believe that is true. But other than that I have found it very helpful and very accurate.

E. Sherman Chase (Boston, Mass.). Apropos of your last statement about the low cost of water, I don't know whether it is in "Nuggets" or somewhere else that I have seen a tabulation of what water costs in the form of watermelon, broccoli and lettuce, and what it costs as delivered by the water-works sytem. I think broccoli is worth about $1,000 a ton of water, as compared to 10 cents as we deliver it.

Edwin L. Jette (New York, N. Y.). Talking about the sale of water by the ton, I had a call last week from a consumer, who said, "How much is water by the ton?" I said, "What are you getting at?" "Well," he said, "I am going to sell 20 tons and, if I get $30 a ton, do you think I will cover the cost?" I said, "You definitely will." Later on he came into the office and said, "How much does water weigh; how much am I going to charge?" We got the books out and figured it according to our rate. He said, "Well, I will charge $30 a ton, and don't you think that will let me come out fairly good?" I told him it would.

Thomas R. Camp (Boston, Mass.). Another thing you have to do is to compare the cost of conveying water with the cost of conveying other materials by freight.

Mr. Jette. I bring that out in many instances. I ask them, "Where can you get anything delivered anywhere in town for the price we charge?" It seems to make them think.

MR. ENSLOW. The cost of delivering water is a very important one, to be sure, and in this respect it is doubly important. The average consumer is apt to ask the water-works man, "Why the need for an increase in rates, where the electric utilities as a rule are reducing rates?" We just heard right on this program that the electric rates are going down instead of up, whereas the water rates have to be raised. I think it was Mr. McDowell who brought that out. It is all a matter of distribution, when you get down to it. You can't put water over an electric wire. Then you also have the interconnection of various electric systems. It does not entail the additional investment that the means of water distribution does. After all, you have a water pipe in there, which takes only so much water, and then you have to put an entirely new pipe in at a tremendous cost, whereas with the electric distribution system they just put a little more voltage on and shove it over the wires, and that is all there is to it.

SIDNEY S. ANTHONY (Augusta, Me.). The electric utilities are increasing rates.

MR. ENSLOW. In most parts of the country they are still coming down.

MR. ANTHONY. The electric rates down here have gone up in the last year or so.

PROCEEDINGS

April 1950 Meeting — Hotel Viking, Newport, R. I.

Thursday, April 20, 1950

President Sidney S. Anthony in the Chair.

The Association was welcomed by Hon. Edmund W. Pardee, Mayor of the city of Newport, R. I.

President Anthony introduced Rear Admiral Thomas Ross Cooley, Commander, U. S. Naval Base, Newport, R. I., who expressed his pleasure in having the Association inspect the Melville Naval Installations.

A paper "Technical Investigations of Additional Ground-Water Supplies in Rhode Island" was read by William B. Allen, Resident Geologist, U. S. Geological Survey, Providence, R. I.

A paper "The Corrosion of Domestic Galvanized Hot-Water Storage Tanks" was read by J. Laird Newell, Research Chemist, Henry Souther Engineering Co., Hartford, Conn.

May 1950 Meeting — Hotel Sheraton, Pittsfield, Mass.

Friday, May 19, 1950

President Sidney S. Anthony in the Chair.

During the luncheon the members of the Association were delightfully serenaded by the American Male Chorus, which was appearing in Pittsfield at that time.

President Anthony introduced Hon. Robert T. Capeless, Mayor of the city of Pittsfield, who welcomed the Association to Pittsfield.

A paper "Recent Water-Supply Developments for Pittsfield, Massachusetts" was read by Nathaniel Clapp, Engineer, Metcalf & Eddy, Boston, Mass.

The members and guests then proceeded in an escorted caravan for an inspection trip to Cleveland Brook Reservoir.

INDEX OF ADVERTISERS

	Page
Atlas Mineral Products Co.	xxvi
Badger Meter Mfg. Co.	Following front cover
Bailey, Howard E.	ii
Builders-Providence, Inc. Division of Builders Iron Foundry	xii
Camp, Thomas R.	ii
Cast Iron Pipe Research Assn.	xxxi
Cement Lined Pipe Co.	iii
Centriline Corporation	Following front cover
Chapman, R. E.	ii
Chemical Fire & Rust Proofing Corp.	xxvi
Eddy Valve Co.	xix
Edson Corp., The	xxi
Eureka Pipe Co., Inc.	xxvi
Fairbanks-Morse Co.	xi
Fay, Spofford & Thorndike	ii
Flexible Sewer Rod Equipment Co.	xxii
Ford Meter Box Co.	Following front cover
Gunite Restorator	ii
Haley & Ward	ii
Hays Mfg. Co.	xvii
Hersey Mfg. Co.	iv
Hilco Supply	xvi
Hughes, Edward F., Co.	iii
Hydraulic Development Corp.	x
Keasbey & Mattison Company	xxviii
Kennedy Valve Mfg. Co.	xiii
Knowles, Morris, Inc.	ii
Koppers Company, Inc.	Following front cover
Layne-New York Co., Inc.	iii
Leadite Co.	Back cover
Leggette, R. M.	ii
Lock Joint Pipe Co.	Following front cover
Ludlow Valve Mfg. Co.	Following front cover
Maher, D. L., Co.	iii
Metcalf & Eddy	ii
Morris Machine Works	xviii
Mueller Co.	Following front cover
National Lead Co. of Mass.	xv
National Water Main Cleaning Co.	viii
Neptune Meter Co.	vii
Northrop & Co.	ix
Omega Machine Co. (Division of Builders Iron Foundry)	v
Pierce-Perry Co.	iii
Pipe Founders Sales Corp.	xxii
Pirnie, Malcolm	iii
Pitometer Co.	iii
Pittsburgh Equitable Meter Co.	Following front cover
Joseph G. Pollard Co., Inc.	xv
H. R. Prescott & Sons	xxvi
% Proportioneers, Inc. %	Following front cover
Red Hed Mfg. Co.	xxiv
Rensselaer Valve Co.	xxvii
Reppucci, C. & Sons, Inc.	iii
Ross Valve Mfg. Co.	xxiii
Smith Mfg. Co., The A. P.	Following front cover
Turbine Equipment Co.	xiv
U. S. Pipe and Foundry Co.	xxxiv
Utilities Supply	xxii
Wallace & Tiernan	xx
Warren Foundry and Pipe Corp.	xxi
Welsbach Corporation	xxv
Weston & Sampson	iii
Whitman & Howard	iii
Wood, R. D., Co.	Following front cover
Worthington Pump and Machinery Corp.	vi

(Classified index on page xxix)

ENGINEERS

HOWARD E. BAILEY

Consulting Sanitary Engineer

Water Works — Water Purification
Sewerage — Sewage Treatment
Industrial Wastes Disposal

6 Beacon St., Boston, Mass.

HALEY & WARD

ENGINEERS

Successors to Frank A. Barbour

Water Works and Sewerage
Valuations
Supervision of Construction and
Operation

TREMONT BUILDING — BOSTON, MASS.

MALden 2-3800

Gunite Restoration Co., Inc.

Specializing in Pressure Concrete and Grouting

665 Salem Street, Malden 48, Mass.

R. E. CHAPMAN COMPANY

Oakdale, Massachusetts

GRAVEL DEVELOPED AND
GRAVEL PACKED WELLS

All Sizes to 60" Diameter

Best Equipped for Complete Test Drilling and Development of Large Supplies

Tel. WEST BOYLSTON 352 / 47-3

CAMP, DRESSER & McKEE

Consulting Engineers

6 Beacon Street
BOSTON 8, MASS.

Water Works and Water Treatment; Sewerage and Sewage Treatment; Municipal and Industrial Wastes; Investigations and Reports; Design and Supervision; Research and Development; Flood Control.

FAY, SPOFFORD & THORNDIKE

ENGINEERS

Charles M. Spofford — Ralph W. Horne
John Ayer — William L. Hyland
Bion A. Bowman — Frank L. Lincoln
Carroll A. Farwell — Howard J. Williams

Water Supply - Sewerage - Drainage
Structural and Foundation Problems

Investigations Reports Designs Valuations
Engineering Supervision

11 BEACON STREET — BOSTON

MORRIS KNOWLES, INC.

Engineers

Water Supply and Purification, Sewerage and Sewage Disposal, Industrial Wastes, Valuations, Laboratory, City Planning.

1312 PARK BUILDING
PITTSBURGH 22, PA.

METCALF & EDDY

ENGINEERS

Water, Sewage, Drainage, Refuse and Industrial Wastes Problems

Airfields — Valuations

Statler Building — 111 Sutter St.
Boston 16 — San Francisco 4

ECKENFELDER ASSOCIATES, INC.

Sanitary Chemists

Sewage and Industrial Waste Surveys, Process Research and Development, Water Analysis, Stream Pollution Investigation, Laboratory Analyses and Reports

45 N. Broad Street, Ridgewood, N. J.

R. M. LEGGETTE

Consulting Ground Water Geologist

Water Supply — Salt Water Problems
Dewatering — Investigations
Recharging — Reports

551 Fifth Avenue — New York 17, N. Y.

ENGINEERS

Malcolm Pirnie Engineers
Civil and Sanitary Engineers
Malcolm Pirnie — Ernest W. Whitlock
Richard Hazen — G. G. Werner, Jr.
Investigations, Reports, Plans, Supervision of Construction and Operations, Appraisals and Rates.
25 West 43rd St. New York 18, N. Y.

THE PITOMETER COMPANY
ENGINEERS
Water Waste Surveys
Trunk Main Surveys
Water Distribution Studies
Penstock Gaugings
50 Church Street — New York City

Edward F. Hughes Co.
Water Works Contractor
Gravel, Artesian and Driven Wells
Foundation Borings
427 Riverside Avenue
Medford 55, Massachusetts

Cement Lined Service Pipe
Cement lined pipe has eliminated corrosion and metal contamination for 60 years.
Write for Literature
Cement Lined Pipe Co.
Lynn, Mass.

D. L. MAHER CO.
Water Supply Contractors
Gravel Wall and Driven Wells
Municipal and Industrial Supplies
38B Brattle Street - KIRkland 1438
Cambridge, Mass.

WESTON & SAMPSON
Consulting Engineers
Water Supply and Sewerage
Chemical and Bacteriological Laboratory
14 BEACON ST. BOSTON, MASS.

WHITMAN & HOWARD
Engineers
Established 1869
Investigations, Designs, Estimates, Reports and Supervision, Valuations, etc., in all Water Works and Sewerage Problems.
89 BROAD ST. BOSTON, MASS.

PIERCE - PERRY CO.
Wholesalers of
Water Works Brass Goods.
Byers Wrought Iron Pipe.
Youngstown Steel Pipe.
Valve and Service Boxes.
236 Congress St., Boston, Mass.
Telephone, Hancock 7817-7818

C. Reppucci & Sons, Inc.
General Contractors
Ground Water Supply
Gravel Packed Wells — Driven Wells
Water Works — Reservoirs
Drainage and Sewerage Works
10 Garden Court St., Boston, Mass.
(Tel. Lafayette 7330)

LAYNE - NEW YORK CO. Inc.
SUCCESSORS TO
Layne-Bowler New England Corp.
Well Water Supply Contractors
New England Headquarters
15 Ryder Street, Arlington, Mass.

WINNERS

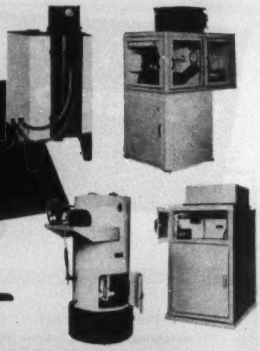
That's the deal you get when you use HERSEY WATER METERS

Our nearest branch will give you all the details

HERSEY MANUFACTURING COMPANY

SOUTH BOSTON, MASS.

BRANCH OFFICES: NEW YORK — PORTLAND, ORE. — PHILADELPHIA — ATLANTA — DALLAS — CHICAGO SAN FRANCISCO — LOS ANGELES



WHEN IT COMES TO *FEEDERS*

Come to

OMEGA

BELT-TYPE GRAVIMETRIC FEEDERS Highly accurate and adaptable, for rates from 10 to 10,000 lbs. per hr.

LOSS-IN-WEIGHT GRAVIMETRIC FEEDERS Tops in accuracy. Sizes for feeding from ½ to 5,000 lbs. per hr.

UNIVERSAL FEEDERS Simple, dependable feeders for dry materials. Capacities: 1 to 5,000 lbs. per hr.

PRECISION SOLUTION FEEDERS Feed liquids by gravity. No valves, pumps, diaphragms. Available for rates from .08 to 500 g.p.h.

DISC FEEDERS For fine, dry materials. Two models for rates from ½ oz. per hr. to 200 lbs. per hr.

ROTODIP SOLUTION FEEDER Meters and feeds liquids at rates up to 800 g.p.h.

ROTOLOCK FEEDERS Volumetric dry feeders, with capacities to 300 cu. ft. per hr.

LIME SLAKERS Designed for water and sewage plants. Capacities from 175 to 10,000 lbs. per hr.

LABORATORY STIRRERS Six paddle units for laboratory coagulation tests.

Also Dust Collectors and Chemical Elevators for use with the above chemical feeders.

Write for Bulletins and engineering information. Address Omega Machine Company (Division of Builders Iron Foundry), Providence 1, Rhode Island.

THE LAST WORD IN FEEDERS

OMEGA

Worthington-Gamon

WATCH DOG WATER METERS

SURE TO MEET YOUR SPECIFICATIONS FOR ACCURACY, LOW MAINTENANCE, LONG LIFE

Before you invest in water meters, get acquainted with the design and performance advantages which make Worthington-Gamon Watch Dog Water Meters first choice of so many municipalities and private water companies in the United States.

WATCH DOG WATER METERS

"Watch Dog" models . . . made in standard capacities from 20 gpm up: frost-proof and split case in household sizes. Disc type, Turbine type or Compound type. Write for Bulletin.

WORTHINGTON-GAMON METER COMPANY

296 South Street, Newark 5, New Jersey

Subsidiary of

WORTHINGTON

PUMP AND MACHINERY CORPORATION

HOW WATER METERS *Save Water*

HERE are just a few examples of the actual water savings effected by meters in all types of towns and cities. These savings represent correction of leakage, careless waste or unauthorized use. In no case do they mean reducing the legitimate use of water. These figures speak for themselves — yet they only begin to tell the story.

For complete factual data, call on your Trident Representative.

NEPTUNE METER COMPANY • 50 West 50th Street • NEW YORK 20, N. Y.
Branch Offices in Chicago, San Francisco, Los Angeles, Portland, Ore., Denver, Dallas, Kansas City, Louisville, Atlanta, Boston.
NEPTUNE METERS, LTD., Long Branch, Ont., Canada

HARTFORD, CONN.

18% metered — Per capita consumption 130 gpd. Pop. 960,000.
100% metered — Per capita consumption 91 gpd. Pop. 1,440,000.

DALLAS, TEXAS

Unmetered — Per capita consumption 100 gpd.
Metered — Per capita consumption 60 gpd.

LOS ANGELES, CAL.

10% metered — Per capita consumption 350 gpd.
100% metered — Per capita consumption 116 gpd.

DANVERS, MASS.

Metering cut consumption 16%, postponed $250,000 expenditure for additional water supply.

PATERSON, N. J.

Unmetered — Per capita consumption 147 gpd. Pop. 126,000.
Metered — Per capita consumption 63 gpd. Pop. 132,000.

ROCHESTER, N. Y.

100% metering "reduced careless consumption so that no acute shortage occurred."

The figures above are quoted from a booklet published by us in 1938. The story they tell applies just as strongly today, as evidenced by the example below:

NAUGATUCK, CONN.

TROUBLE — Consumption increase from 700 million to 1 billion 100 million gallons threatened water shortage.

REMEDY — Universal metering with Trident Water Meters.

RESULTS — Saving on domestic consumption (first year) approximately 60%. Universal Trident Metering revealed unaccounted for (wasted) water amounted to 25%, helped to reduce it to 14%, the overall saving making available additional 1 mgd, worth $29,200 per year. Investment in metering — $35,000; increased storage facilities for equivalent additional water supply would have cost many times that.

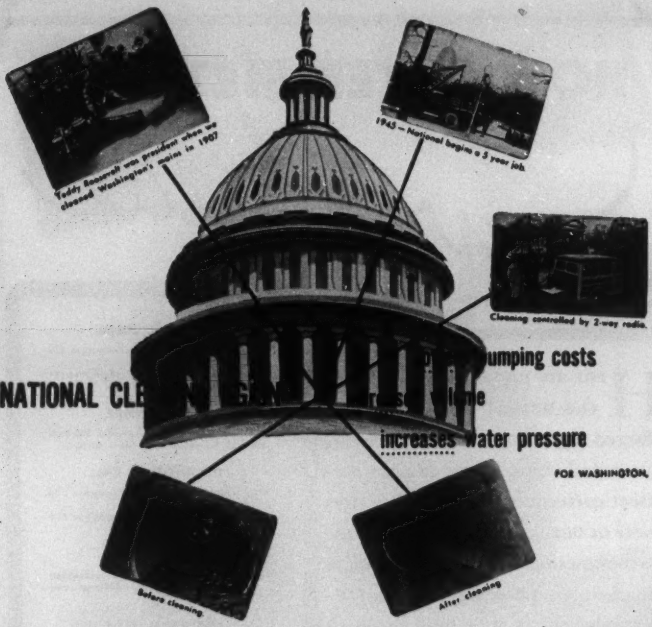
METERING ALONE IS NOT ENOUGH...

"It must not be taken for granted," writes a prominent Water Works General Superintendent and Chief Engineer, *"that with the installation of meters all troubles come to an end. Meters must be properly maintained ... Many a water company has become careless in meter maintenance, and as meter efficiency decreased, has looked to increased rates ... A properly maintained meter department is the most important part of any water system."* Trident Meters, simple, and rugged, with 100% interchangeability of parts, are easy and economical to maintain, at "new meter accuracy" through years of constant service.

TRIDENT WATER METER

215

NEPTUNE METER COMPANY • 50 West 50th Street • NEW YORK 20, N. Y.
Branch Offices in Chicago, San Francisco, Los Angeles, Portland, Ore., Denver, Dallas, Kansas City, Louisville, Atlanta, Boston.
NEPTUNE METERS, LTD., Long Branch, Ont., Canada


Teddy Roosevelt was president when we cleaned Washington's mains in 1907
1945 — National begins a 5 year job
Cleaning controlled by 2-way radio
umping costs
increases water pressure
FOR WASHINGTON, D. C.
Before cleaning
After cleaning

NATIONAL CLE

Way back in 1907 and again in 1926 National successfully cleaned the water mains of Washington, D. C.

In 1945 a five year program to clean and recondition the entire water main system of Washington was begun and National in conjunction with the Centriline Corporation was again awarded the cleaning contract for 1945, 1946, 1947, 1948 and 1949 — *in short, the entire cleaning job!*

Tests made on those lines already cleaned and centrilined indicate a co-efficient of over 130 as against less than 90 before cleaning, resulting in lower pumping costs, increased volume and higher pressure.

Let us estimate the cost of restoring your lines to at least 95% of their original carrying capacity. Write today.

NATIONAL WATER MAIN CLEANING COMPANY

29

50 Church Street, New York 7, N. Y.

ATLANTA, 333 Candler Building • ATLANTA, 1221 Mortgage Guarantee Building • BOSTON, 115 Peterboro Street • CHICAGO, Room 1336, 122 So. Michigan Avenue • FLANDREAU, S. D., 315 No. Crescent Street • HOUSTON, 2578 Grant Street • KANSAS CITY, 422 BMA Building • LITTLE FALLS, N. J., Box 91 • LOS ANGELES, 448 South Hill Street • OMAHA, 3812 Castellar Street • RICHMOND, 210 East Franklin Street • SALT LAKE CITY, 149-151 Second So. Street • SAN FRANCISCO, 681 Market Street • SIGNAL MOUNTAIN, TENN., 204 Slaxton Street • WACO, P. O. Box 887 • MONTREAL, 2028 Union Ave. • VANCOUVER, B. C., 505 West 1st Ave. • WINNIPEG, 576 Wall Street • HAVANA • MAYAGUEZ,, PUERTO RICO • BOGOTA • CARACAS • MEXICO CITY

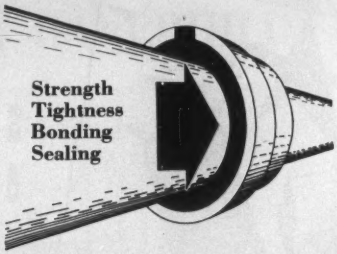
BOND-O

Homogenized

SELF CAULKING COMPOUND

Every bag of BOND-O is a bag of perfect jointing compound.

NORTHROP & CO. INC.
SPRING VALLEY, NEW YORK



THIS SPACE AVAILABLE FOR

YOUR ADVERTISEMENT

(See inside back cover for rates)

OVER 35 YEARS
of Dependable Service To All New England

H. R. PRESCOTT & SONS
110 NORTH PARKWAY, WORCESTER, MASSACHUSETTS
Telephone 3-7535 Day or Night

For a Complete Line of Water Works Supplies

CALL ON US

CATALOGS UPON REQUEST

STAR PERFORMERS ACROSS THE NATION

In show business only the best get star billing. It takes years of outstanding performances to win public acclaim.

Bookings in Water Departments everywhere tell a story of star performance by HYDRO-TITE and FIBREX . . . Joints that don't leak . . . that are bacteria-free.

HYDRO-TITE, *with over 35 years of dependable service,* is the easy-melting, self-sealing compound for bell and spigot joints. Comes in powder, packed in 100 lb. moisture-proof bags—and in solid LITTLEPIGS in handy 50 lb. cartons. 1/5 the cost of lead!

FIBREX, the chemically treated, bacteria-free, joint packing . . . comes in 3/8", 1/2", 5/8" sizes in 60 lb. reels. 1/2 the cost of braided jute! 1/4 the cost of rubber!

Let these stars perform for you.

Free working samples on request.

HYDRO-TITE and FIBREX IN STOCK IN

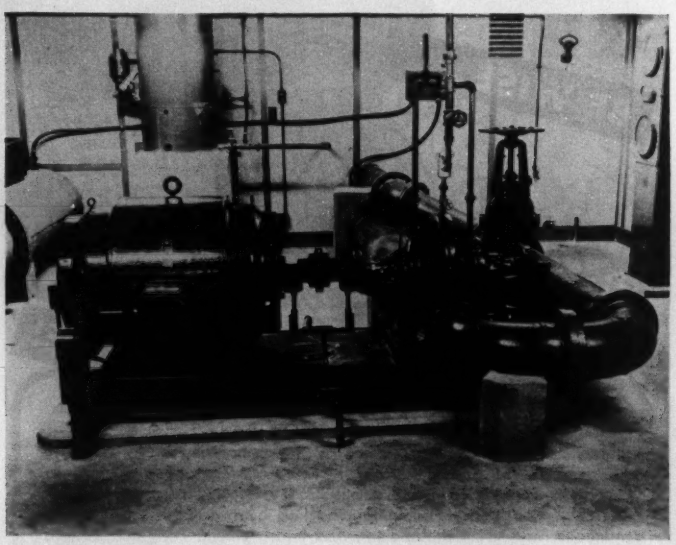
Portland, Oregon	Seattle, Wash.
Kansas City, Mo.	Memphis, Tenn.
Birmingham, Ala.	Orlando, Fla.
Little Falls, N. J.	Boston, Mass.

HYDRAULIC DEVELOPMENT CORP.

MAIN SALES OFFICE **50 CHURCH ST., N. Y. C.**

General offices and works **W. Medford Sta., Boston, Mass.**

WATER FOR HAVERHILL



1750 G.P.M. Fairbanks-Morse Motor Driven Pumping Unit at City of Haverhill, Mass. Kenoza Lake Pumping Station.

The City of Haverhill in order to insure an abundant water supply, recently installed at each of its three pumping stations, Johnson's Pond, Crystal Lake, and Kenoza Lake, a Fairbanks-Morse Fig. 5813 6" 1750 G.P.M. Centrifugal Pump driven by a Fairbanks-Morse 125 H.P. 1800 R.P.M. QZK Motor.

A trained Fairbanks-Morse Engineer is on call to help solve YOUR pumping problems.

Write or telephone to:

FAIRBANKS, MORSE & CO.

178 Atlantic Avenue **Boston 10, Massachusetts**

Telephone: LAfayette 3-3600

FOR FLOW MEASUREMENT AND CONTROL OF LIQUIDS, AIR, DRY MATERIALS

BE WISE . . .

BUILDERS

Instruments

STANDARDIZE!

Builders offers you a complete line of FLOW metering and controlling equipment — tested and approved by actual use throughout the water-works field. For accuracy and dependability, it pays to standardize on BUILDERS — the modern equipment backed by over half a century of continuous research, development, and improvement. For Bulletins and engineering recommendations, address Builders-Providence, Inc. (Division of Builders Iron Foundry), Providence 1, R. I.

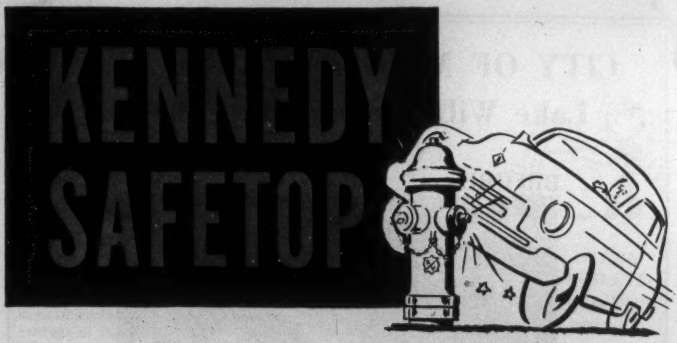
PHONE

Providence, GAspee 1-4302 or Boston, Liberty 2-7171

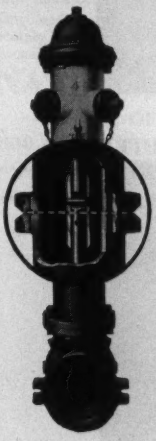
BUILDERS PRODUCTS

THE VENTURI METER • TYPE M SUPER-ACCURATE FLOW METERS
FLO-WATCH MECHANICAL FLOW METERS • PROPELOFLO METERS
CHRONOFLO TELEMETERS • CHRONOFLO ELECTRIC FLOW METERS
CHRONOFLO CONTROLLERS • CHLORINIZERS-CHLORINE GAS FEEDERS
KENNISON OPEN FLOW NOZZLES • SIGHTFLO INDICATORS
CONVEYOFLO CONTINUOUS WEIGHING SCALES
LIQUID LEVEL GAUGES, RECORDERS AND CONTROLLERS

BUILDERS PROVIDENCE
Instruments



The Hydrant that Cuts the Cost of Traffic Accidents



Wherever a fire hydrant faces the hazards of traffic . . . the community is safer, maintenance is lower, when it is a KENNEDY Safetop.

The whole secret is in the Safety Breakable Section (see enlarged inset on illustration). Notice the standpipe breaking ring. It has been so engineered that its strength is equal to that of the standpipe wall itself. This means that a KENNEDY Safetop Hydrant will stand up without breaking under any ordinary impact. But . . . the stresses are so distributed that when the breaking point is reached it breaks cleanly at the groove in the breaking ring.

The inexpensive stem coupling and breaking ring are the only parts to break . . . above ground where they are easily and quickly repaired. There's less damage to the car that hits it. Repair costs are a fraction of a below-ground break or of a fractured standpipe. The neighborhood does not risk curtailed fire protection for a protracted period.

ONE MAN in less than fifteen minutes, can permanently repair a KENNEDY Safetop Fire Hydrant broken in a traffic accident. A wrench, sledge hammer, screwdriver and a collision repair kit, consisting of a new Standpipe Breaking Ring, a new Stem Coupling, two pins and a gasket, are all he needs!

Send for your copy of Safetop Bulletin.

THE KENNEDY VALVE MFG. CO.
1033 EAST WATER ST.
ELMIRA, NEW YORK

VALVES • PIPE FITTINGS • FIRE HYDRANTS

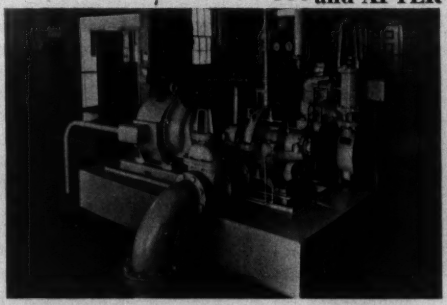
OFFICE-WAREHOUSES IN NEW YORK, CHICAGO, SAN FRANCISCO • SALES REPRESENTATIVES IN PRINCIPAL CITIES

CITY OF MARLBOROUGH MASS.

Lake Williams Pumping Station

BEFORE - - -

- - - and AFTER



METCALF & EDDY, Consulting Engineers

TURBINE EQUIPMENT COMPANY OF NEW ENGLAND

80 Federal Street **Phone LIberty 2-5993** **Boston 10, Mass.**

New England Representatives for

DE LAVAL STEAM TURBINE COMPANY

TRENTON, NEW JERSEY

Ingot or Wool?

Whether the caulking job calls for ingots for cast lead joints or lead wool for cold caulking, the primary requirement in either case is lead of high purity.

Don't take chances with inferior caulking lead which may have been manufactured from scrap material containing a large percentage of impurities.

When present in a caulked joint, impurities on the surface will corrode and cause weak spots. The stresses due to normal pipe movement concentrate at these areas and failure results.

Our lead, both in ingot and wool form, is made from selected metals and carries the Lead Industries Association Seal of Approval as a guarantee of its quality.

OTHER PRODUCTS—

LEAD PIPE
SOLDER
WHITE LEAD
RED LEAD

NATIONAL LEAD COMPANY

OF MASSACHUSETTS

800 Albany Street **Boston 6, Massachusetts**

M-SCOPE Pipe Finder

LIGHTWEIGHT MODEL

Catalog No. 25F

On Request

JOSEPH G. POLLARD CO., Inc.

Pipe Line Equipment

New Hyde Park **New York**

Tel. SUDBURY 458 P. O. BOX 153

HILCO SUPPLY

delivers

A Complete Line of Waterworks Supplies To All New England

Quality Products — Fast, Courteous and Dependable Service

At the Junction of Routes 20 and 27
SOUTH SUDBURY, MASSACHUSETTS

THE HEFFERNAN PRESS

PRINTERS
and
PUBLISHERS

150 Fremont Street
Worcester, Massachusetts

FOR
MORE
THAN
80
YEARS

HAYS

Prices Consistent With Quality

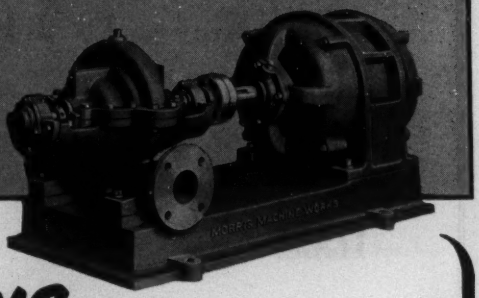
Water Service Products

Hays Manufacturing Company

Erie, Pennsylvania

FLOATING Sealing Rings...

Permit CLOSER Running Clearances



MORRIS HORIZONTAL SPLIT Double-Suction WATER PUMP

No other pump has the Floating Sealing Rings . . . yet this exclusive feature alone makes the Morris Double-Suction Water Pump outstanding for efficiency and long service.

During the instant that the pump comes up to speed, but before full pressure is built up, the Morris Floating Sealing Rings adjust themselves to a uniformly close running clearance around the impeller. As soon as full speed is developed, the internal hydraulic pressure acting upon the vertical face of the Floating Ring, presses it tightly against the precision machined surface of the casing ring where it is firmly held in place.

This action permits machining the rings to closer clearances. Leakage is consequently reduced to a minimum, initial efficiency maintained for much longer periods of service. Assures concentricity of ring with impeller and eliminates binding due to abnormal operating conditions.

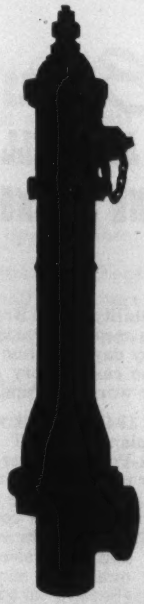
NEW ENGLAND REPRESENTATIVES
Starkweather Engineering Co.
Newtonville, Massachusetts
Telephone: Bigelow 4-8042

MORRIS MACHINE WORKS
Baldwinsville, N. Y.
Sales Offices in Principal Cities

MORRIS *Centrifugal Pumps*

EDDY

Valves and Hydrants

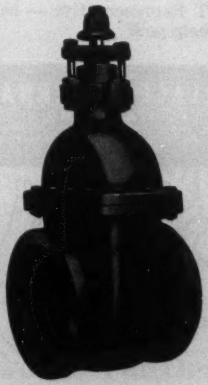


Distinctive Features of the EDDY Valves

ONLY three parts are moved by the Stem—the ball and the two gates. Each gate is hung from one of the trunnions on the ball. A convex surface at the base of each trunnion fits a concave surface on the back of the gate. This allows the gates to adjust themselves properly to their seats. . . . The gates, being free to revolve on the trunnions, do not always seat in the same position. Gates are center bearing and adjustable. They are forced to their seats with equal pressure at all points. There are two hooks on the ball on sizes 4-inch and larger, which loosely engage with the gates.

Distinctive Features of Our New Swivel Top Hydrants

THIS new hydrant has all the advantages of the popular EDDY fire hydrant, plus several additional features. . . . Nozzles are in a short flanged section of the standpipe, which may be unbolted and turned to different positions. . . . Should the standpipe be broken, only the casting below the swivel head need be replaced.



. . . To raise the hydrant to conform to a new grading, simply insert a flanged extension piece below the swivelhead. No digging. To add a steamer nozzle at any time, it is only necessary to replace the swivel head with one having a steamer nozzle.

Besides valves and hydrants to meet the most exacting demands of waterworks service, the complete EDDY Line includes: valves for sewage disposal works; valves for steam, gas and oil; check valves, foot valves, plug valves, shear gates, indicator posts, etc. EDDY valves are made in three classes: Iron Body Bronze Mounted, All Bronze, and All Iron Valves.

Eddy Valve Co.

WATERFORD NEW YORK

8 YEARS AND STILL GOING STRONG

The ability of the Break-Point Process to meet the various demands of day by day operation is aptly shown by the case history of a municipal water works in Pennsylvania.

Since 1941, when it was installed at this plant by W&T Engineers, the Break-Point Process has played a major role in producing a pure, sparkling water for the system's many consumers. It has completely eliminated complaints on tastes and odors and has raised the finished water quality to such a high level that tests show *no* gas formers and *no* bacteria on the plates. In addition, a staff report continues, the Break-Point Process was of particular value in keeping the water acceptable to consumers during an emergency plant overload of 120%.

These accomplishments and such additional benefits as longer filter runs and iron and manganese removal are typical of what you receive with the Break-Point Process backed by W&T Equipment.

In the complete line of W&T chlorinating equipment, proved by over 35 years' experience all over the world, there is a chlorinator that will give *your* plant these benefits, too.

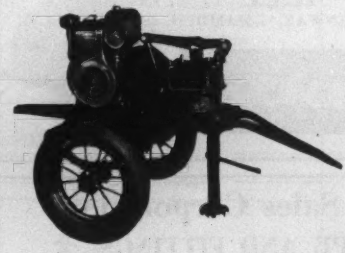
For more details write to your nearest W&T Representative — he'll be glad to help you.

WALLACE & TIERNAN
COMPANY, INC.
CHLORINE AND CHEMICAL CONTROL EQUIPMENT
NEWARK 1, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES

S-44

EDSON

PUMPS and ACCESSORIES



POWER and HAND

Edson Diaphragms

Depco Centrifugals

Edson Special Hose

Edson Strainers, Foot Valves and Couplings

Pipe Locators - Thawers

THE EDSON CORPORATION

49 D STREET, SOUTH BOSTON, MASSACHUSETTS

Telephone SOuth Boston 8-3041

Warren Foundry & Pipe Corp.

ALSO

Warren Pipe Co. of Mass., Inc.

SALES OFFICES

55 LIBERTY STREET, NEW YORK

75 FEDERAL STREET, BOSTON, MASS.

Manufacturers of

CAST IRON PIPE

Flanged Pipe *Flexible Joint Pipe*

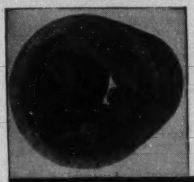
Bell and Spigot Pipe

Special Castings *Short Body B. & S. Specials*

Warren (WF) Spun Centrifugally Cast Iron Pipe

WORKS: PHILLIPSBURG, N. J. and EVERETT, MASS.

Large Stock Enables Us to Make Prompt Shipments



Get Full Service From Old Mains

The most practical way to meet today's overload demand is to clean clogged water mains. FLEXIBLE Underground Pipe Cleaning Co., specializes in such jobs— any size—2″ to 72″.

RAY BAHR

41 GREENWAY, HAMDEN, CONNECTICUT

New England Representative

Pipe Founders Sales Corporation

CAST IRON PIPE AND FITTINGS

FOR

Water, Steam, Gas and Culverts

Special Flanged and Bell and Spigot Castings

Lyncast Iron Chemical Castings

Office: 6 Beacon Street, Boston **Warehouse and Yard: East Cambridge, Mass.**

UTILITIES SUPPLY CORPORATION

Distributors of Water Works Supplies and Materials for Mains and Services

Revere Copper Tubing, Type K

Hays Brass Goods and Erie Service Boxes

Buffalo Gate and Service Boxes

Cast Iron Fittings—AWWA or Short Pattern

Mineralead Jointing Compounds

Construction Tools: Shovels, Cold Cutters, Lanterns, Picks, Sledges.

Jointing Materials: Twisted or Braided Jute, Runners, Pots, Ladles, Hydro Rings, Pig Lead and Lead Wool.

Furnaces: Complete Hauck Line.

Office and Warehouse

425 Riverside Avenue

MEDFORD, MASSACHUSETTS

My 8-9023

My 8-9024

1879—ROSS— 1879

AUTOMATIC VALVES

Controls elevation of water in tanks, basins and reservoirs

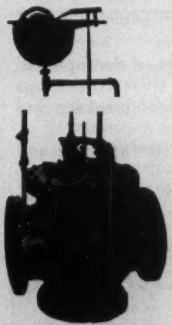
ALTITUDE VALVE

1. Single Acting
2. Double Acting

Maintains desired discharge pressure regardless of change in rate of flow

REDUCING VALVE

Regulates pressures in gravity and pump systems; between reservoirs and zones of different pressures, etc.



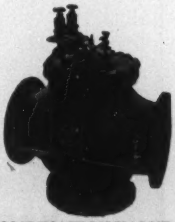
Maintains levels in tank, reservoir or basin

1. As direct acting

2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.

FLOAT VALVE

A self contained unit, with controls three or more automatic



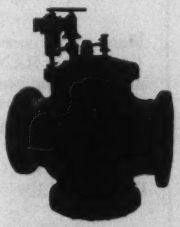
COMBINATION VALVE

Combination automatic control both directions through the valve.

Maintains safe operating pressures for conduits, distribution and pump discharge

SURGE-RELIEF VALVE

Electric remote control—solenoid or motor can be furnished



REMOTE CONTROL VALVE

Adapted for use as primary or secondary control on any of the hydraulically controlled or operated valves.

ROSS VALVE MFG. CO., INC. Box 592 TROY, N. Y.

Reg. U. S. Pat. Off.

Fig. 226

Iron Pipe or Hall Thread

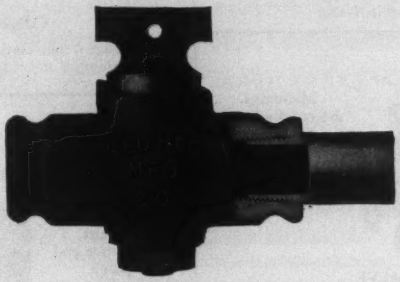


Fig. 220

THERE IS A DIFFERENCE

in the quality **of brass goods used with under ground water service pipes.**

Many experienced Water Works Managers have expressed that opinion. RED HED HAND GROUND PLUGS fitted to all RED HED Stops and Corporations, reduce to a minimum the liability of breakage and leakage.

Replacing leaking or broken Stops or Corporations is expensive and annoying.

OVER A PERIOD OF YEARS RED HED BRASS GOODS HAVE PROVEN LESS COSTLY.

RED HED MFG. CO.

Manufacturers of

RED HED Brass Goods for Water Works

368 Congress Street **Boston 10, Mass.**

No question about it; the most popular beverage of all is good drinking water—water that tastes right, smells right and looks right.

And there's no reason for water not to be "right." Where Welsbach Ozonating equipment is used, consumers know the pleasure of drinking water free from disagreeable chlorinous odors, offensive "medicinal" tastes and objectionable color.

The biggest Ozone installation in the world (serving the Belmont filtration area in Philadelphia) proves that through Welsbach, cities can get the most efficient type of water treatment at a cost that's kind to the taxpayers.

• • •

Everybody wants improved drinking water—and all communities can now have it. Water technicians, city officials and consulting engineers particularly will be interested in the Welsbach-Ozone story. They are invited to write about their water difficulties to The Welsbach Corporation. A frank, factual analysis will be made—at no cost or obligation. Also ask for, "Are Bathless Thursdays Really Necessary?", the picture story booklet about the Welsbach-Ozone process and equipment.

THE WELSBACH CORPORATION

Ozone Processes Division

1500 Walnut Street, Philadelphia 2, Pennsylvania

Tegul-Mineralead* AND HYDE-RO RINGS

the best way to join bell and spigot pipe

Tegul-Mineralead is easy and clean to work with, economical, too — needs no skilled labor, caulking or deep bell holes. HYDE-RO RINGS, rubber ring packing, are recommended for use with Tegul-Mineralead. Please write us at 17 Walnut Street, Mertztown, Penna., and request Bulletin No. M10-1 and M10-5.

THE ATLAS MINERAL PRODUCTS COMPANY
MERTZTOWN, PENNA. HOUSTON, TEXAS

*Trade Mark Registered

THE HEFFERNAN PRESS

•

PRINTERS

AND

PUBLISHERS

•

150 FREMONT STREET

WORCESTER, MASSACHUSETTS

Attention Mr. Water Works Superintendent ! !

CEMENT LINED SERVICE PIPE:—

Resists Corrosion

Has proven practical for nearly three-quarters of a century

Immediate delivery can be made to waterworks on both wrought iron and steel, black or galvanized.

"SPECIFY EUREKA PIPE"

EUREKA PIPE COMPANY, Inc.

Manufacturers of CENTRIFUGAL CEMENT LINED PIPE and LEAD AND TIN LINED FITTINGS

591-593 WASHINGTON ST. TEL. 3-9550 LYNN, MASS.

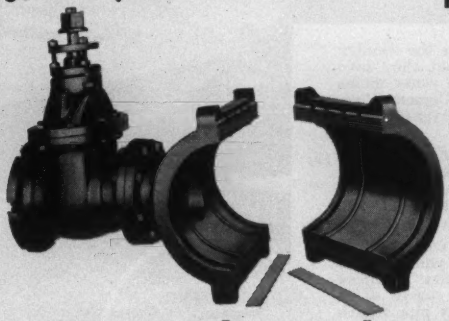
Chemical Fire and Rust Proofing Corp.

Lining and Coating of Pipe, Couplings, Joints, Tanks, Piling, Structural Steel with Bituminous Enamel or Hydraulic Cement in strict conformity with AWWA Specifications.

Ask for quotations

84½ Berkeley Street, Boston, Mass — LIberty 2-5185

For a quick Tap... and permanent Connection



RENSSELAER TAPPING SLEEVES *and* VALVES

The ideal combination for rapidly and easily making branch line connections to mains under pressure. Designed and built to resist line pressures and caulking strains.

Rugged·Simple·Efficient

FOR QUICK REPAIRS

Rensselaer Repair Sleeves make it easy to repair pipe lines. Similar to tapping sleeves, with exception of outlet connections.

FOR PIPE CROSSES

The Rensselaer Tapping Cross is extra heavy, with features found on regular tapping sleeves. Thousands have been used with uniformly perfect results.

Make the Job 100% RENSSELAER

TAPPING Valves are our Standard Double Disc Gate Valves fitted with oversize seat rings to permit the use of full size cutters. Flange on one end is machined and drilled for perfect alignment with sleeves and crosses. Adaptor flange fits all standard tapping machines. SLEEVES are extra heavy, with lead gaskets to provide a watertight joint the *full length* of the sleeve. Centering rings provide a stop for caulking, and also save caulking materials. Let a Rensselaer Representative tell you further about this and other Rensselaer products.

LEADERSHIP FOR OVER 65 YEARS

RENSSELAER VALVE COMPANY

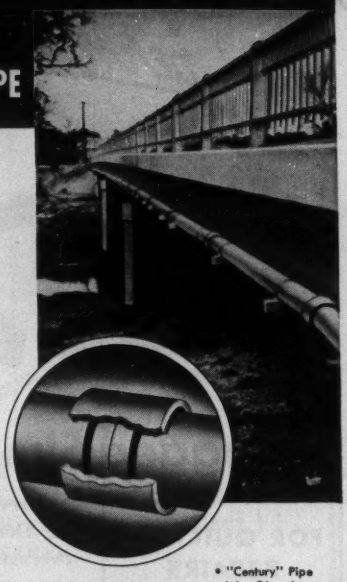
Hydrants • Gate Valves • Square Bottom Valves
Check Valves • Tapping Sleeves and Valves • Air Release Valves

TROY, NEW YORK

Division of Neptune Meter Company

Atlanta, Bala-Cynwyd, Pa., Chicago, Dallas, Denver, Haverhill, Mass., Kansas City, Los Angeles, Memphis, Oklahoma City, Pittsburgh, San Francisco, Seattle

Save on water main costs with easy-to-install "Century" ASBESTOS-CEMENT PIPE



Hundreds of communities the country over have discovered that they save dollars by the mile with water mains of "Century" Asbestos-Cement Pipe. This modern main cuts over-all water system costs three ways:

First, the initial cost of the pipe is moderate. And, because "Century" Pipe is so light-weight and strong, it is easy and economical to haul and to handle.

Next, "Century" Pipe costs less to install—no heavy laying equipment is needed. And the "Century" Simplex Couplings* let you lay curves of as much as 5° deflection per pipe length quickly and easily.

Finally, you get real, long-term system economy. "Century" Pipe is made of two practically indestructible materials —asbestos fiber and Portland cement. It cannot tuberculate—inside diameter, initial flow capacity, and pumping costs remain constant. Being non-metallic, "Century" Pipe defies electrolysis, is highly resistant to soil corrosion, needs no protective coating. You can count on "Century" Asbestos-Cement Pipe to last longer with a minimum of maintenance!

* "Century" Pipe with Simplex Couplings supported on bridge. Note that "Century" Pipe needs no protective painting —external corrosion factors can't affect it either in the ground or in open air. Insert photo is cut-away of assembled Simplex Coupling.

***WHAT YOU SHOULD KNOW ABOUT SIMPLEX COUPLINGS**

Made of the same materials as "Century" Pipe—asbestos fiber and Portland cement.

Only three parts—an asbestos-cement sleeve, and two specially compounded round rubber gaskets. Couplings are assembled quickly and easily.

"Century" Simplex Couplings give you a combination of immediately and permanently tight joints that are, at the same time, flexible and vibration resistant.

In the photo above, you see light-weight "Century" Pipe supported over a creek bed. The Simplex Couplings every 13 ft. act as expansion joints—actually absorb the bridge vibration of passing traffic.

Nature made Asbestos . . . Keasbey & Mattison has made it serve mankind since 1873

• Before you specify or buy any water main pipe, it will pay you to investigate "Century" Asbestos-Cement Pipe. Write us for complete information.

KEASBEY & MATTISON
COMPANY • AMBLER • PENNSYLVANIA

K&M best in asbestos ®

CLASSIFIED DIRECTORY OF ADVERTISEMENTS

AIR COMPRESSORS.
Edson Corp., The xxi

ASBESTOS CEMENT PIPE.
Keasbey & Mattison Company xxviii

BRASS GOODS.
Eureka Cement Lined Pipe Co. xxvi
Hays Mfg. Co. xvii
Hilco Supply xvi
Mueller Co. ..... Following front cover
Pierce-Perry Co. iii
Red Hed Mfg. Co. xxiv
Smith Mfg. Co., The A. P. ..... Following front cover

CALKING MACHINERY AND TOOLS.
Hydraulic Development Corp. x
Mueller Co. ..... Following front cover
Northrop & Co. ix

CAST IRON PIPE. (See Pipe, Cast Iron.)

CEMENT LINED PIPE. (See Pipe, Cement Lined.)

CHEMICAL FEED APPARATUS.
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) xii
Omega Machine Co. v
% Proportioneers, Inc. % ..... Following front cover
Wallace & Tiernan Co., Inc. xx

CHLORINATORS.
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) xii
% Proportioneers, Inc. % ..... Following front cover
Wallace & Tiernan Co., Inc. xx

CLEANING WATER MAINS.
Flexible Underground Pipe Cleaning Co. xxii
National Water Main Cleaning Co. viii

COCKS, CURBS AND CORPORATIONS.
Eureka Cement Lined Pipe Co. xxvi
Hays Mfg. Co. xvii
Mueller Co. ..... Following front cover
Pierce-Perry Co. iii
Smith Mfg. Co., The A. P. ..... Following front cover

CONCRETE PIPE. (See Pipe, Concrete.)

CONSTRUCTION AIR TOOLS.
Edson Corp., The xxi

CONTRACTORS' EQUIPMENT.
Hydraulic Development Corp. x
Northrop & Co. ix

CONTRACTORS.
Layne-New York Co. iii
Maher, D. L. Co. iii
Reppucci, C. & Sons iii

CURB BOXES.
Eureka Cement Lined Pipe Co. xxvi
Hays Mfg. Co. xvii
Hilco Supply xvi
Mueller Co. ..... Following front cover
Pierce-Perry Co. iii
H. R. Prescott & Sons xxvi

DIAPHRAGMS, PUMPS.
Edson Corp., The xxi
% Proportioneers, Inc. % ..... Following front cover

ENGINEERS.
Bailey, Howard E. ii
Camp, Dresser and McKee ii
Fay, Spofford and Thorndike ii
Haley and Ward ii
Knowles, Morris, Inc. ii
Metcalf and Eddy ii
Pirnie Engineers, Malcolm iii
Weston and Sampson iii
Whitman and Howard iii

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

ENGINES. (See Pumps and Pumping Engines.)

EQUIPMENT. (See Contractors' Equipment.)

FEED WATER FILTERS.
- % Proportioneers, Inc. % ..... Following front cover
- Ross Valve Mfg. Co., Inc. xxiii

FILTRATION PLANT EQUIPMENT.
- Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) xii
- % Proportioneers, Inc. % ..... Following front cover

FLAP VALVES.
- Eddy Valve Co xix

FLEXIBLE JOINTS.
- U. S. Pipe and Foundry Co. xxxiv

FURNACES.
- Hilco Supply xvi
- Hydraulic Development Corp. x
- Leadite Co. ..... Back cover
- Mueller Co. ..... Following front cover
- Northrop & Co. ix
- H. R. Prescott & Sons xxvi

GATE VALVES. (See Valves.)

HOSE, SUCTION AND CONDUCTION.
- Edson Corp., The xxi
- H. R. Prescott & Sons xxvi

HYDRANTS, FIRE.
- Eddy Valve Co. xix
- Hilco Supply xvi
- Kennedy Valve Mfg. Co. xiii
- Mueller Co. ..... Following front cover
- H. R. Prescott & Sons xxvi
- Rensselaer Valve Co. xxvii
- Smith Mfg. Co., The A. P. ..... Following front cover
- Wood, R. D., Co. ..... Following front cover

HYDRANTS, PUMPS.
- Edson Corp., The xxi
- Hilco Supply xvi
- H. R. Prescott & Sons xxvi

LEAD.
- National Lead Co. of Mass. xv

LEAD PIPE. (See Pipe, Lead.)

LEAD WOOL.
- National Lead Co. of Mass. xv

LEAK FINDERS.
- Edson Corp., The xxi

METERS, OIL AND WATER.
- Badger Meter Mfg. Co. ..... Following front cover
- Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) xii
- Hersey Mfg. Co. iv
- Neptune Meter Co. vii
- Pipe Founders Sales Corp. xxii
- Pittsburgh Equitable Meter Divn. ..... Following front cover
- Worthington-Gamon Meter Co. vi

METER COUPLINGS.
- Badger Meter Mgf. Co. ..... Following front cover
- Ford Meter Co. xvi
- Hays Mfg. Co. xvii
- Hersey Mfg. Co. iv
- Mueller Co. ..... Following front cover
- Neptune Meter Co. vii
- Red Hed Mfg. Co. xxiv
- Smith Mfg. Co., The A. P. ..... Following front cover
- Worthington-Gamon Meter Co. vi

METERS (Venturi Type.)
- Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) xii

METER BOXES.
- Ford Meter Co. xvi
- Mueller Co. ..... Following front cover

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

METER TESTERS.
Badger Meter Mfg. Co. ..... Following front cover
Ford Meter Co. ..... Following front cover
Mueller Co. ..... Following front cover
Neptune Meter Co. vii

OIL ENGINES.
Edson Corp., The xxi
Fairbanks, Morse Co. xi

OZINATION EQUIPMENT.
Welsbach Corp. xxv

PIPE, BRASS.
Hilco Supply xvi
Pierce-Perry Co. iii
H. R. Prescott & Sons xxvi

PIPE, CAST IRON (and Fittings.)
Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) xii
Cast Iron Pipe Research Association xxxiii
Hilco Supply xvi
Pipe Founders Sales Corp. xxii
H. R. Prescott & Sons xxvi
U. S. Cast Iron Pipe and Foundry Co. xxxiv
Warren Foundry and Pipe Co. xxi
Wood, R. D. Co. ..... Following front cover

PIPE, CEMENT LINED.
Cast Iron Pipe Research Association xxxiii
Cement Lined Pipe Co. iii
Eureka Cement Lined Pipe Co. xxvi
Pipe Founders Sales Corp. xxii
U. S. Pipe and Foundry Co. xxxiv

PIPE, COATING AND LININGS.
Barrett Division ..... Following front cover
Centriline Corp. ..... Following front cover
Koppers Company, Inc. ..... Following front cover

PIPE, CONCRETE.
Lock Joint Pipe Co. ..... Facing front cover

PIPE CUTTING MACHINES.
Smith Mfg. Co., The A. P. ..... Following front cover

PIPE JOINTING MATERIAL.
Atlas Mineral Products Co. xxvi
Hilco Supply xvi
Hydraulic Development Corp. x
Leadite Co., The ..... Back cover
National Lead Co. of Mass. xv
Northrop & Co. ix

PIPE, LEAD.
National Lead Co. of Mass. xv
Pierce-Perry Co. iii
Red Hed Mfg. Co. xxiv

PIPE LINING.
Centriline Corp. ..... Following front cover

PIPE, PRESTRESSED CONCRETE.
Lock Joint Pipe Co. ..... Facing front cover

PIPE, WROUGHT IRON AND STEEL.
Pierce-Perry Co. iii

PLUG VALVES.
Eddy Valve Co xix
Hays Mfg. Co. xvii
Mueller Co. ..... Following front cover
Pittsburgh Equitable Meter Divn. ..... Following front cover

PITOMETERS.
Pitometer Co., Engrs. iii

PORTABLE AIR COMPRESSORS. (See Air Compressors.)

PRESSURE REGULATORS.
Hilco Supply xvi
Mueller Co. ..... Following front cover
Pittsburgh Equitable Meter Divn ..... Following front cover
H. R. Prescott & Sons xxvi
Ross Valve Mfg. Co., Inc. xxiii

PROVERS, WATER.
Badger Meter Mfg. Co. ..... Following front cover

CLASSIFIED DIRECTORY OF ADVERTISEMENTS *(Continued)*

PUMPS AND PUMPING MACHINES.
- Edson Corp., The ... xxi
- Fairbanks, Morse and Co. ... xi
- Layne-New York Co., Inc. ... iii
- Hilco Supply ... xvi
- Maher Co., D. L. ... iii
- Morris Machine Works ... xviii
- H. R. Prescott & Sons ... xxvi
- Ross Valve Mfg. Co., Inc. ... xxiii
- Turbine Equipment Co. ... xiv

RATE CONTROLLERS AND GAUGES.
- Badger Meter Mfg. Co. ... Following front cover
- Builders-Providence, Inc. (Divn. of Builders Iron Fdry.) ... xii

SHEAR GATES.
- Eddy Valve Co ... xix
- Mueller Co. ... Following front cover

SLEEVES AND VALVE TAPPINGS.
- Eddy Valve Co ... xix
- Hilco Supply ... xvi
- Mueller Co. ... Following front cover
- H. R. Prescott & Sons ... xxvi
- Rensselaer Valve Co. ... xxvii
- Smith Mfg. Co., The A. P. ... Following front cover

SUPPLIES AND TOOLS.
- Hilco Supply ... xvi
- Hydraulic Development Corp. ... x
- Leadite Co., The ... Back cover
- Mueller Co. ... Following front cover
- Northrop & Co. ... ix
- Pierce-Perry Co. ... iii
- H. R. Prescott & Sons ... xxvi

TAPPING MACHINES.
- Hays Mfg. Co. ... xvii
- Mueller Co. ... Following front cover
- Red Hed Mfg. Co. ... xxiv
- Smith Mfg. Co., The A. P. ... Following front cover

TAPPING SLEEVES. (See Sleeves and Valves, Tapping.)

VALVE BOXES.
- Eddy Valve Co ... xix
- Hilco Supply ... xvi
- Kennedy Valve Mfg. Co. ... xiii
- Mueller Co. ... Following front cover
- Pierce-Perry Co. ... iii
- Pipe Founders Sales Corp. ... xxii
- H. R. Prescott & Sons ... xxvi
- Smith Mfg. Co., The A. P. ... Following front cover
- Wood, R. D. Co. ... Following front cover

VALVE INSERTING MACHINES.
- Mueller Co. ... Following front cover
- Smith Mfg. Co., The A. P. ... Following front cover

VALVES, CHLORINE.
- Wallace and Tiernan Co., Inc. ... xx

VALVES, GATE.
- Eddy Valve Co ... xix
- Hilco Supply ... xvi
- Kennedy Valve Mfg. Co. ... xiii
- Mueller Co. ... Following front cover
- Pierce-Perry Co. ... iii
- H. R. Prescott & Sons ... xxvi
- Rensselaer Valve Co. ... xxvii
- Smith Mfg. Co., The A. P. ... Following front cover
- Wood, R. D. Co. ... Following front cover

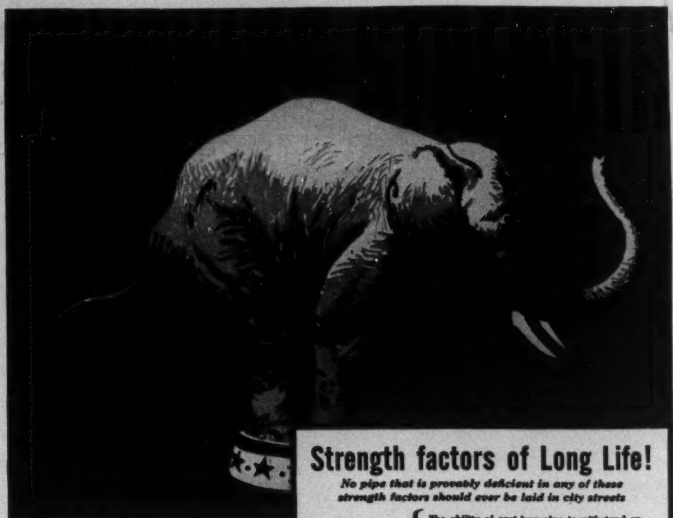
VALVES, REGULATING.
- Mueller Co. ... Following front cover
- Ross Valve Mfg. Co., Inc. ... xiv

WATER WASTE DETECTION.
- Pitometer Co., The ... iii

WELL CONNECTIONS.
- Red Hed Mfg. Co ... xxiv

WELLS, GRAVEL, FILTER AND DRIVEN.
- Edward F. Hughes Company ... iii
- Maher Co., The D. L. ... iii

WROUGHT IRON PIPE. (See Pipe, Wrought Iron and Steel.)



Without crushing strength—or, for that matter—without all of the strength factors listed opposite—no pipe laid 100 years ago in *city streets* would be in service today. But, in spite of the evolution of traffic from horse-drawn vehicles to heavy trucks and buses—and today's vast complexity of subway and underground utility services—cast iron gas and water mains, laid over a century ago, are serving in the streets of more than 30 cities in the United States and Canada. Such service records prove that cast iron pipe combines all the strength factors of long life with ample margins of safety. No pipe that is provably deficient in any of these strength factors should ever be laid in city streets. Cast Iron Pipe Research Association, Thos. F. Wolfe, Engineer, 122 So. Michigan Ave., Chicago 3.

Strength factors of Long Life!

No pipe that is provably deficient in any of these strength factors should ever be laid in city streets

CRUSHING STRENGTH — The ability of cast iron pipe to withstand external loads imposed by heavy fill and unusual traffic loads is proved by the Ring Compression Test. Standard 6-inch cast iron pipe withstands a crushing weight of more than 14,000 lbs. per foot.

BEAM STRENGTH — When cast iron pipe is subjected to beam stress caused by soil settlement, or disturbance of soil by other utilities, or resting on an obstruction, tests prove that standard 6-inch cast iron pipe in 10-foot span sustains a load of 18,000 lbs.

SHOCK STRENGTH — The toughness of cast iron pipe which enables it to withstand impact and traffic shocks, as well as the hazards in handling, is demonstrated by the Impact Test. While under hydrostatic pressure and the heavy blows from a 50 pound hammer, standard 6-inch cast iron pipe does not crack until the hammer is dropped 6 times on the same spot from progressively increased heights of 6 inches.

BURSTING STRENGTH — In full length bursting tests standard 6-inch cast iron pipe withstands more than 1500 lbs. per square inch internal hydrostatic pressure, which proves ample ability to resist water-hammer or unusual working pressures.

CAST IRON PIPE SERVES FOR CENTURIES

Painted for U. S. Pipe & Foundry Co. by Paul Laune

There's a solid satisfaction in specifying cast iron pipe. You know that your choice coincides with the judgment of leaders of your profession the world over. And when the line is backfilled, you are confident that it will serve throughout a long life at a low annual maintenance cost. This has been true of cast iron pipe for centuries; yet in the fifty-one years since our Company was founded, notable advances in manufacturing methods and controls have been made, resulting in a finer, more uniform pipe. United States Pipe and Foundry Company, General Offices: Burlington, N. J. Plants and Sales Offices Throughout U. S. A.

U.S.
cast iron
PIPE
FOR WATER, GAS, SEWERAGE AND INDUSTRIAL SERVICE

The Journal of the New England Water Works Association

is a quarterly publication, containing the papers read at the meetings, together with reports of the discussions. Many of the contributions are from writers of the highest standing in their profession. It affords a convenient medium for the interchange of information and experience between the members, who are so widely separated as to find frequent meetings an impossibility. Its success has more than met the expectation of its projectors; there is a large and increasing demand for its issues, and every addition to its subscription list is a material aid in extending its field of usefulness.

All members of the Association receive the JOURNAL for three dollars per annum which sum is included in their annual dues; to all others the subscription is four dollars per annum.

TO ADVERTISERS

THE attention of parties dealing in goods used by Water Department is called to the JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION as an advertising medium.

Its subscribers include the principal WATER WORKS ENGINEERS AND CONTRACTORS in the United States. The paid circulation is 1,100 COPIES.

Being filled with original matter of the greatest interest to Water Works officials it is PRESERVED and constantly REFERRED TO BY THEM, and advertisers are thus more certain to REACH BUYERS than by any other means.

The JOURNAL is not published as a means of revenue, advertising being inserted solely to help meet the large expense of publication.

ADVERTISING RATES

	One Issue	Four Issues
One Page	$ 48.00	$120.00
Half Page	30.00	75.00
Quarter Page	18.00	45.00
Eighth Page	11.00	27.00
One Page, 2 Colors	48.00	272.00
Back Cover	100.00	250.00
Cards, 1/12 Page	8.00	20.00

Size of page, 6½ x 7½ net.

A sample copy will be sent on application.

For further information, address the Advertising Agent,

MRS. ALICE R. MELROSE,
73 TREMONT STREET,
BOSTON 8, MASSACHUSETTS

LEADITE

COSTS ARE REDUCED WHEN *LEADITE* IS USED

Of course, the greatest advantage in using LEADITE, is, that it makes a good, tight joint,—and thus reduces leakage to a minimum,—but LEADITE also offers the following advantages, which are worthy of serious consideration: Saves caulking expenses—Reduces cost of digging large bell-holes—Saves in cost of material—Reduces time required for pumping "wet trenches"—Saves time in preparation—Saves time in handling on the job—Saves in freight and hauling charges.

Another point, LEADITE saves "interest charges" by speeding up the completion of the water line.

The true value of LEADITE is best indicated by the fact that it has been used on THOUSANDS OF MILES of Water Mains,—all over this Country, as well as in many Overseas Countries.

The Pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%.

THE LEADITE COMPANY

Girard Trust Company Building — Philadelphia, Penna.